COASTAL CONTROLS ON VERTICAL SOUND SPEED DETERMINATION AND CORRECTIONS TO ECHO SOUNDINGS

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NAVAL POSTGRADUATE SCHOOL
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THESIS

COASTAL CONTROLS ON VERTICAL
SOUND SPEED DETERMINATION AND
CORRECTIONS TO ECHO SOUNDINGS

by

David Winston Yeager

June 1979

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COASTAL CONTROLS ON VERTICAL SOUND SPEED DETERMINATION AND CORRECTIONS TO ECHO SOUNDINGS		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; June 1979
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) David Winston Yeager, LCDR, NOAA		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE June 1979
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Naval Postgraduate School Monterey, California 93940		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Echo sounding, corrections to echo sounding, vertical sound speed profiling, velocity corrections, hydrography, coastal sound speed determination

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Present methods for determining sound speed corrections for echo soundings in continental shelf areas are time-consuming and expensive. This study was undertaken to determine whether or not sound speed correctors of sufficient accuracy could be deduced from historical data.

Historical sound speed data for an east coast, shelf area indicates that temporal and spatial variability exceeds acceptable

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(Page 1) S/N 0102-014-6601 |

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Examination of temperature and salinity data indicates that historical salinity values in the region are sufficiently stable to allow acceptable sound speed corrections to be made derived on the basis of in-situ temperature measurement and historically derived salinity values. Expendable bathythermograph probes are capable of meeting temperature requirements.

The constancy of the T-S relation in such regions may allow salinity determination from water temperatures alone.

Coastal Controls on Vertical Sound Speed Determination and Corrections to Echo Soundings

by

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OCEANOGRAPHY (HYDROGRAPHY)

from the

NAVAL POSTGRADUATE SCHOOL
June 1979

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Present methods for determining sound speed corrections for echo soundings in continental shelf areas are time-consuming and expensive. This study was undertaken to determine whether or not sound speed correctors of sufficient accuracy could be deduced from historical data.

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Examination of temperature and salinity data indicates that historical salinity values in the region are sufficiently stable to allow acceptable sound speed corrections to be made derived on the basis of in-situ temperature measurement and historically derived salinity values. Expendable bathythermograph probes are capable of meeting temperature requirements.

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ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to LCDR A. B. Chace, USN, and CDR D. E. Nortrup, NOAA, as thesis advisor and reader, for encouragement and guidance throughout this project.

I am especially indebted to LCDR Alan Pickrell, NOAA, for his invaluable assistance in developing programming for this analysis.

I would also like to thank Dr. R. G. Paquette for his kind assistance and permission to utilize existing computer programs written by him. Further, I would like to extend my appreciation to Mr. Henry Odum of the National Oceanographic Data Center for his timely assistance in providing the data tapes used in this study.

Finally, I would like to thank my wife for her patience and understanding during this undertaking.

I. INTRODUCTION

A. GENERAL

The objective of this thesis was the application of basic oceanographic principles to the solution of an operational hydrographic problem. Depths determined by echo sounder are based on an assumed speed of sound in seawater. Corrections must be applied to such depths to account for the difference between the assumed and actual speed of sound. Present practice dictates that in-situ measurement of the sound speed profile in a working area be made and depth corrections computed. The problem is to determine if temporal and spatial sound speed variability in continental shelf areas is small enough to allow use of historical salinity and temperature data archived in the National Oceanographic Data Center's (NODC) Oceanographic Station File to correct echo soundings. Historical data was examined to determine whether or not correctors of sufficient accuracy could be obtained from historical data without resort to in-situ measurements.

Applicability of historical data (in the form of temperature and salinity measurements) has been widely discussed but limits of applicability have not been well-documented (Mobley, 1977).

This study was undertaken to examine the historical data available, its variability within a sample coastal region, and limitations on application in meeting National Ocean Survey (NOS) hydrographic requirements.

Echo Sounders (or fathometers) do not measure depth directly but rather measure the time delay between an outgoing sound pulse and the return echo of this pulse. Depth is then derived by dividing the round trip travel time by two and multiplying this value by the assumed speed of sound in sea-water. The fathometer makes this transformation electronically or mechanically within the device itself and displays depth of water beneath the transducer. The depth displayed is the nominal or fathometer depth. True depth can be determined only if the soundspeed profile through the water column is known and used to calculate depth as in the following equation:

$$Z = \frac{1}{2}\int_0^{2\Delta t} V(Z_t)dt \qquad (1)$$

"Where $V(Z_t)$ is the sound speed at the level Z_t where the signal passes at the time $0<t<2\Delta t$. Corrected depth is derived from nominal depth by applying a correction according to some standardized procedure" (Greenberg and Sweers, 1972).

Most echo sounders used in hydrographic surveying are constructed with a calibrated speed of sound assumed in the device. This speed is usually either 1463 meters per second (800 fathoms per sec) or 1500 meters per second (820 fathoms per second). Reference speeds are chosen to represent realistic ocean values which are convenient for design. Echo sounders in use by the National Ocean Survey at present are calibrated with an assumed sound speed of 1463 meters per

second. This value is reasonably near the actual speeds encountered in most waters surveyed by NOS (Umbach, 1976).

Sound speed corrections are applied to bring standardized values close to actual vertical column sound speeds for a location (Umbach, 1976).

Field measurements are made during the course of a survey in order to determine representative vertical sound speed profiles. These field measurements and their reduction are often time consuming, expensive and result in considerable conjecure regarding areas and times of corrector applicability.

B. ACCURACY REQUIREMENTS

The requirements for accuracy of echo soundings for hydrographic surveys are based on standards agreed to by member states of the International Hydrographic Bureau (IHB). Depth measurement requirements are stated in Special Publication 44, "Accuracy Standards Recommended for Hydrographic Surveys", published by the IHB in 1968. These standards vary with depth and may be summarized as follows (Umbach, 1976):

(a) 0-11 fathoms - - - - - - - - - - 1.0 ft.
(b) 11-55 fathoms - - - - - - - - - 3.0 ft.
(c) Deeper than 55 fathoms - - - - 1% of depth

These standards represent the maximum allowable errors in measurement of depth due to all sources, including variation of sound speed in the water column. "Accuracies attained for hydrographic surveys conducted by the National Ocean Survey shall equal or exceed those given by the IHB (Umbach, 1976)."

The National Ocean Survey's requirements for accuracy in determining the speed of sound for correcting echo soundings are stated as follows: "The velocity of sound must be known with sufficient accuracy to ensure that no sounding will be in error by as much as 0.25% of the depth from this cause alone. Therefore the mean velocity of sound must be known to within ±4 meters per second" (Umbach, 1976). These standards apply only to conventional echo sounding systems and survey operations involving these systems. An implicit assumption is that the sound pulse or "beam" is vertical.

Future systems under test by NOS such as the BS^3 (Bathymetric Swath Sonar System) will require greater accuracies. This is due to the fact that many beams are projected at varying angles through the water column to attain swath coverage. Figure 1 is a diagram of such a system. The longer acoustic path lengths, as well as varying trajectories, makes this technique more sensitive to sound speed error than present vertical depth measurements. Accuracy requirements for such a system have been stated as ±2 meters per second (Mobley, 1977).

C. HISTORICAL TECHNIQUES

A brief review of historical techniques utilized by the hydrographer for determination of sound speed is necessary in order to properly appreciate the magnitude of the problem.

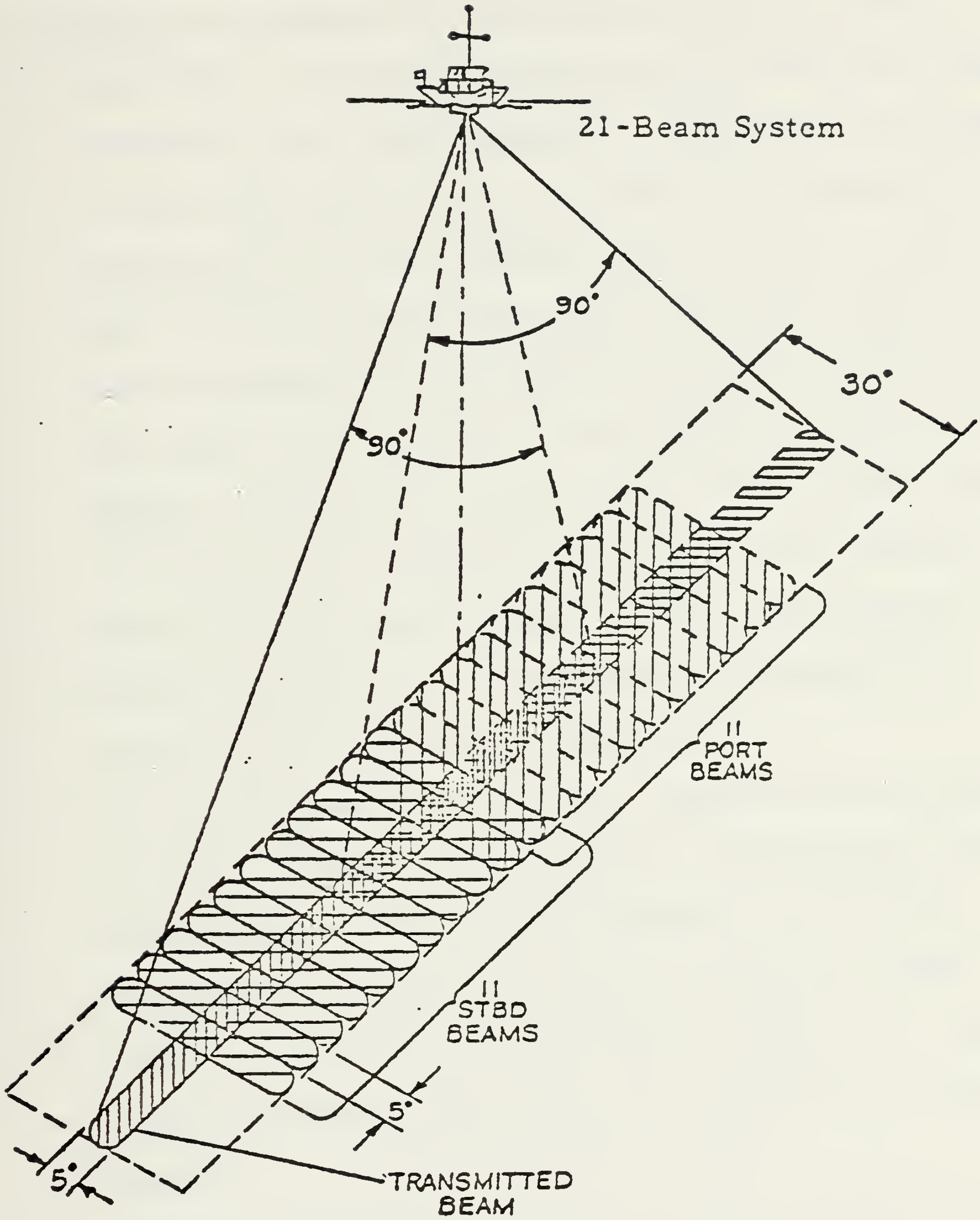

Figure 1

Schematic Representation of BS^3

Sounding System Showing Swath Coverage

(From Mobley, 1978)

There have been at least four common methods used to determine either the sound speed profile or the correction in depth units to be applied to soundings (Maunsell, 1976).

1) Bar checks or leadline comparisons in which the depth recorded by the echo sounder is compared to the depth of the reflecting surface of the "bar" lowered to a known depth, or the leadline depth to the bottom. This procedure has usually been limited to use in shallow depths due to problems of manuevering the bar under the transducer, and correct gauging of the depths indicated by the leadline. This method gives a correction to be applied to the nominal depths indicated by the echo sounder. Sound speed may be determined from depth differences provided that draft of the transducer is known.

2) Direct measurement of salinity temperature and depth by either Nansen casts, salinity, temperature and depth sensors (STD) or the expendable STD (XSTD). Sound speeds at various standard depths are then computed using an equation relating salinity, temperature and pressure to speed, such as Wilson's 1960 equation.

3) Direct measurement of sound velocity as a function of depth by lowering a sound velocimeter to various depths and recording the speeds obtained at these depths. These devices have been poorly utilized in

the past due to design limitations. The development of an expendable Sound Velocimeter (XSV) makes this device promising for the future.

4) Historical tables or atlases of sound speeds or salinity and temperature data observed in the same area and season as the operations. Tables such as Matthews Tables (Matthews, 1939) and Heck and Service's Tables (Heck & Service, 1924) have been in use for quite some time with periodic efforts being made to improve upon the accuracy of results obtained (Ryan, 1974). These tables have not been generally applied to depths of 200 meters or less (Sherwood, 1974).

In general then, there have been a variety of methods employed, some utilizing direct measurement and others utilizing historical information. All of the methods summarized have been noted for deficiencies or disadvantages of one form or another. Adequate direct measurements of the sound speed profile in the operational area provide the best accuracy; however, in terms of expense and efficiency, there may be useable alternatives.

D. MEASUREMENT AND COMPUTATIONAL REQUIREMENTS - SOUND SPEED EQUATIONS

Sound speeds in a fluid may be calculated with various equations relating speed to density and elasticity of the medium. The following equation extracted from "Fundamentals of Acoustics" by Kinsler and Frey relates speed of sound in

a fluid to the isothermal bulk modulus (B_T), the ratio of specific heats (Γ) and density in kg/m^3 (ρ_0). Isothermal bulk modulus is an elastic modulus measuring the difficulty of compressing a liquid (Kinsler and Frey, 1962).

$$C = \sqrt{\frac{\Gamma \beta_T}{\rho_0}} \qquad (2)$$

In the case of seawater, these properties are functions of salinity, temperature and pressure (Ryan, 1974).

Standard practice within the National Ocean Survey has been to use a form of Wilson's 1960 equation for the speed of sound as a function of salinity, temperature and pressure (Umbach, 1976). The usual case has been to calculate the in-situ speed profile from oceanographic observations within a project area. This empirical equation was developed as a "best fit" to certain measured data. The 1960 equation was an improvement over earlier versions in order to expand the range of applicability. The equation is stated by Wilson to fit data within the ranges of temperature from -4°c to 30°c, salinities from 0 °/₀₀ to 37 °/₀₀ and pressures between 1 kg/cm^2 and 1000 kg/cm^2. This equation is said to have achieved a standard deviation of 0.30 meters/second from the mean for all data obtained (Wilson, 1960).

It has been noted by other researchers that significant accuracy improvements have been achieved in determining sound speeds utilizing equations that fit data limited to real

seawater conditions (LeRoy, 1969). One of the two equations formulated by LeRoy in 1968 "fit Wilson's second equation for seawater to within 0.1 meter/second in the domain described and the other fits Wilson's corresponding data with a better accuracy than does Wilson's equation" (LeRoy, 1969). Other equations such as those formulated by Frye and Pugh in 1971 also claim similar improvement (.1m/sec error estimate) (Frye and Pugh, 1971).

These variations are discussed as a means of pointing out possible error sources and improvements to techniques to achieve desired accuracies in sound speed determinations.

Wilson's 1960 equation is stated in the Journal of the Acoustical Society of America, October 1960 as follows:

$$
\begin{aligned}
V &= 1449.14+V_T+V_P+V_S+V_{STP} \\
V_T &= 4.5721T-4.4532\mathrm{X}10^{-2}T^2-2.6045\mathrm{X}10^{-4}T^3 \\
&\qquad +7.9851\mathrm{X}10^{-6}T^4 \\
V_P &= 1.60272\mathrm{X}10^{-1}P+1.0268\mathrm{X}10^{-5}P^2 \\
&\qquad +3.5216\mathrm{X}10^{-9}P^3-3.3603\mathrm{X}10^{-12}P^4 \qquad (3) \\
V_S &= 1.39799(S-35)+1.69202\mathrm{X}10^{-3}(S-35)^2 \\
V_{STP} &= (S-35)(-1.1244\mathrm{X}10^{-2}T+7.7711\mathrm{X}10^{-7}T^2 \\
&\quad +7.7016\mathrm{X}10^{-5}P-1.2943\mathrm{X}10^{7}P^2+3.1580\mathrm{X}10^{-8}PT \\
&\quad +1.5790\mathrm{X}10^{-9}PT^2)+P(-1.8607\mathrm{X}10^{-4}T \\
&\quad +7.4812\mathrm{X}10^{-6}T^2+4.5283\mathrm{X}10^{-8}T^3) \\
&\quad +P^2(-2.5294\mathrm{X}10^{-7}T+1.8563\mathrm{X}10^{-9}T^2) \\
&\qquad +P^3(-1.9646\mathrm{X}10^{-10}T).
\end{aligned}
$$

In this equation the units of temperature, pressure, salinity, and sound speed are °C, kg/cm^2, parts per thousand, and meters/sec, respectively. This equation is essentially the same as that given in the NOS Hydrographic Manual with the exception of the term containing variation of gravity with latitude. This term is used if pressure is not measured but computed from depth. The equation as stated in the Hydrographic Manual is:

$$V_u = 1449.14+V_P+V_\phi+V_S+V_T+V_{STP} \qquad (4)$$

"Where V_u is the speed of sound in meters per second, Vp is a correction for pressure, $V\phi$ is a correction for variation of gravity with latitude, V_S is a correction for salinity, V_T is a correction for temperature and V_{STP} is a correction for the combined effect of salinity, temperature and pressure" (Umbach, 1976). All terms in equation 4 are the same as those in equation 3 with the exception of the V_ϕ term. V_ϕ may be determined by reference to tabulated values in Table 12C of Special Publication 68,"Handbook of Oceanographic Tables" published by the U.S. Naval Oceanographic Office in 1966.

It has been necessary to examine these equations in order to determine the effects which small variations in temperature or salinity have on the results attained.

As stated in the Hydrographic Manual, utilizing Wilson's Equation, temperature measurement accuracies of ±1°C and salinity measurement accuracies of ±1ppt are required to satisfy sound speed correction requirements (Umbach, 1976).

An analysis of the Wilson equation was performed by Testing Division, Office of Marine Technology (OMT), NOAA in 1976 to determine sensitivity of the equation to variations of temperature and salinity (Bivins, 1976). Their results were stated as follows: "if corrections were made on the basis of temperature measurement with a one sigma (1σ) accuracy of $\pm.1°$c, a natural variability of ±3ppt (1σ) from the measured salinity could be tolerated and the NOS sound speed accuracy of ±4 meters per second would be satisfied" (Bivins, 1976).

This analysis pointed out that the most critical measurement was temperature and if temperature accuracies of .1°C were met then salinity measurement errors within a larger range than previously noted could be tolerated.

The accuracy requirements, as well as the OMT analysis all bear on the acceptability of historical information for this application. In fact, the requirements stated are the criteria for acceptance or rejection of the technique proposed.

Sound speed corrections are computed within NOS by the "Summation of layers" method (Umbach, 1976). Once temperatures and salinities have been determined at standard depths, sound speeds at mid-layer depths are computed by graphical or numerical methods. These layer corrections are then summed to produce the total sound speed corrections applicable to given depths (Umbach, 1976). Layer thicknesses utilized in this procedure are specified in the "NOS Hydrographic Manual" as 10 meters for depths to 200 meters.

II. PROCEDURE AND METHODOLOGY

A. STUDY AREA

The area selected for study was a coastal region off-shore of Charleston, South Carolina. It was originally decided to examine a one-degree "square" extending from latitude 32°N to latitude 33°N and longitude 79°W to longitude 80°W. The study area was subsequently enlarged slightly in order to add additional data points near the northeast corner of the one-degree square. Figure 2 is an index map showing the study area.

The area was chosen on the basis of several factors:

First, it appeared to be representative of the oceanographic environments characteristic of east coast survey areas. The influx of estuarine waters in the nearshore area, bottom topography, depth range and other physical features are similar to those noted for shelf waters from Georgia to the Virginia Capes.

Second, the size of the region selected was typical of a one-year hydrographic project by a single coastal survey ship, or a six-month project by two ships.

Third, examination of the Environmental Data Service's "Key to Oceanographic Records Documentation No. 2, Temperature, Salinity, Oxygen and Phosphate in Waters off United States" showed the data density in this region to be representative of that in nearshore regions along the East Coast. Some 300

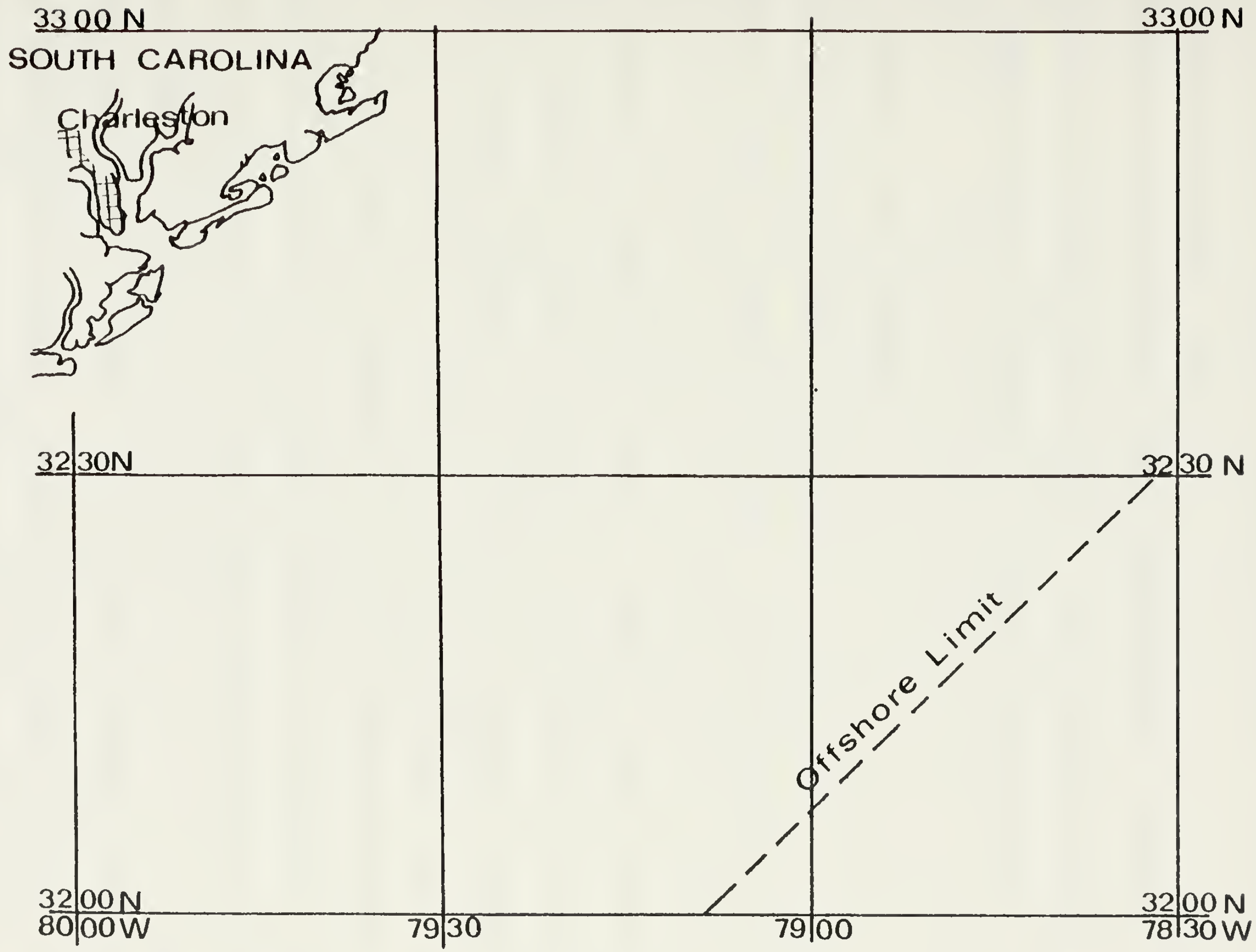

Figure 2

Index Map of Study Area

Nansen cast stations dating from 1966 to 1975 were included within this area.

Finally, the area also corresponded to NODC data format and limitations of existing computer programs for abstracting and manipulating this data.

The area extends from shore approximately fifty-five NM offshore (to the 200 meter curve). The majority of the region has a depth range of eighteen to seventy-three meters (10 to 40 fathoms). Bottom topography is gently sloping until the shelf break is encountered.

Surface circulation is seasonal in character and is influenced by the following factors: river run-off, horizontal temperature gradients, wind and coriolis force effects on tidal motions in restricted waters (Bumpus and Lauzier, 1965).

The region is mainly inshore of the Gulf Stream although the Gulf Stream affects its circulation patterns (Gaskell, 1972). No systematic study of seawater movement has been made, though several generalizations have been based on limited data from drift bottles (Kuroda and Marland, 1973).

The surface circulation has been characterized as having a prevailing northerly drift during the winter and spring (Bumpus and Lauzier, 1965). The pattern becomes less well-defined during the summer. During the summer transitional period there is water movement both to the south and to the north. The northerly movement is apparent in the very near shore region and over the outer edge of the shelf. Between these two motions is a southerly flow (Bumpus and Lauzier, 1965).

During the autumn, most of the region is under the influence of a southerly drift, with the exception of the outer portion of the shelf, where the flow is toward the northeast (Bumpus and Lauzier, 1965). Current speeds are maximum during the winter and autumn and a minimum during the summer months (U.S. Naval Oceanographic Office, 1965).

Kuroda and Marland (1973) noted that the surface circulation in this region is strongly dependent on the prevailing winds.

Figure 3 is a diagram exhibiting the seasonal nature of the surface currents in the area extracted from the American Geographical Society's "Serial Atlas of the Marine Environment, Folio 7".

Systematic study regarding water mass distribution or temperature and salinity distribution is limited in this region (Kuroda and Marland, 1973). The Bureau of Commercial Fisheries R/V THEODORE N. GILL studied this region in 1953 (Kuroda and Marland, 1973). Kuroda and Marland (1973) in "Physical and Chemical Properties of the Coastal Waters of Georgia" summarized the GILL data. Figure 4 is a station plan for the GILL cruises.

This data shows that the isotherms trend northeast and southwest, paralleling the coastline and the approximate axis of the Gulf Stream. Monthly minimum temperatures were observed inshore and maximums generally seen in the offshore areas. Minimum surface temperatures (10°-23°C) occurred in January and February and maximum temperatures (27°-29°C) occurred in June and July (Kuroda and Marland, 1973). Minimum and maximum

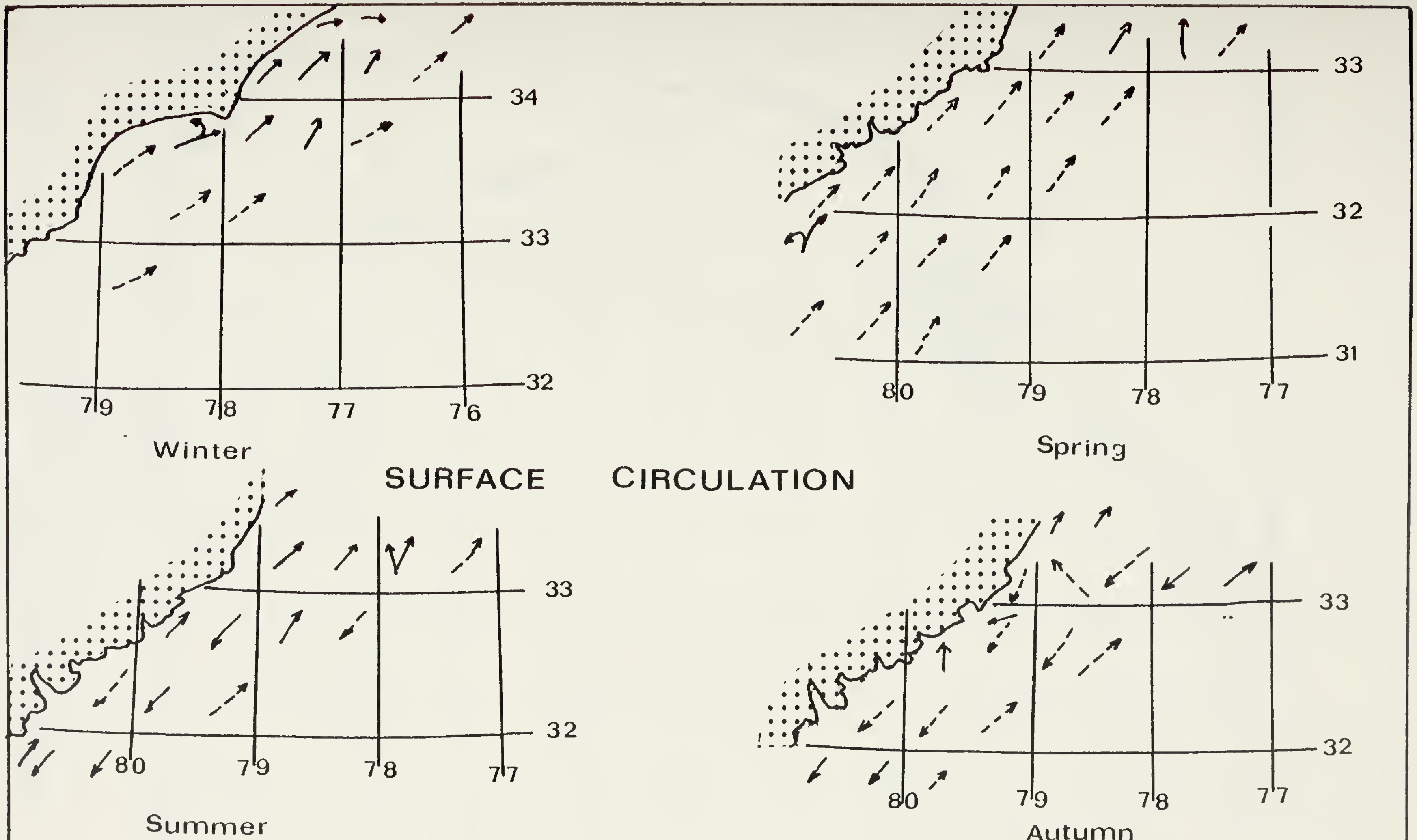

Figure 3

Dashed Arrows Represent Data Extrapolated
or Inferred from Limited Observation

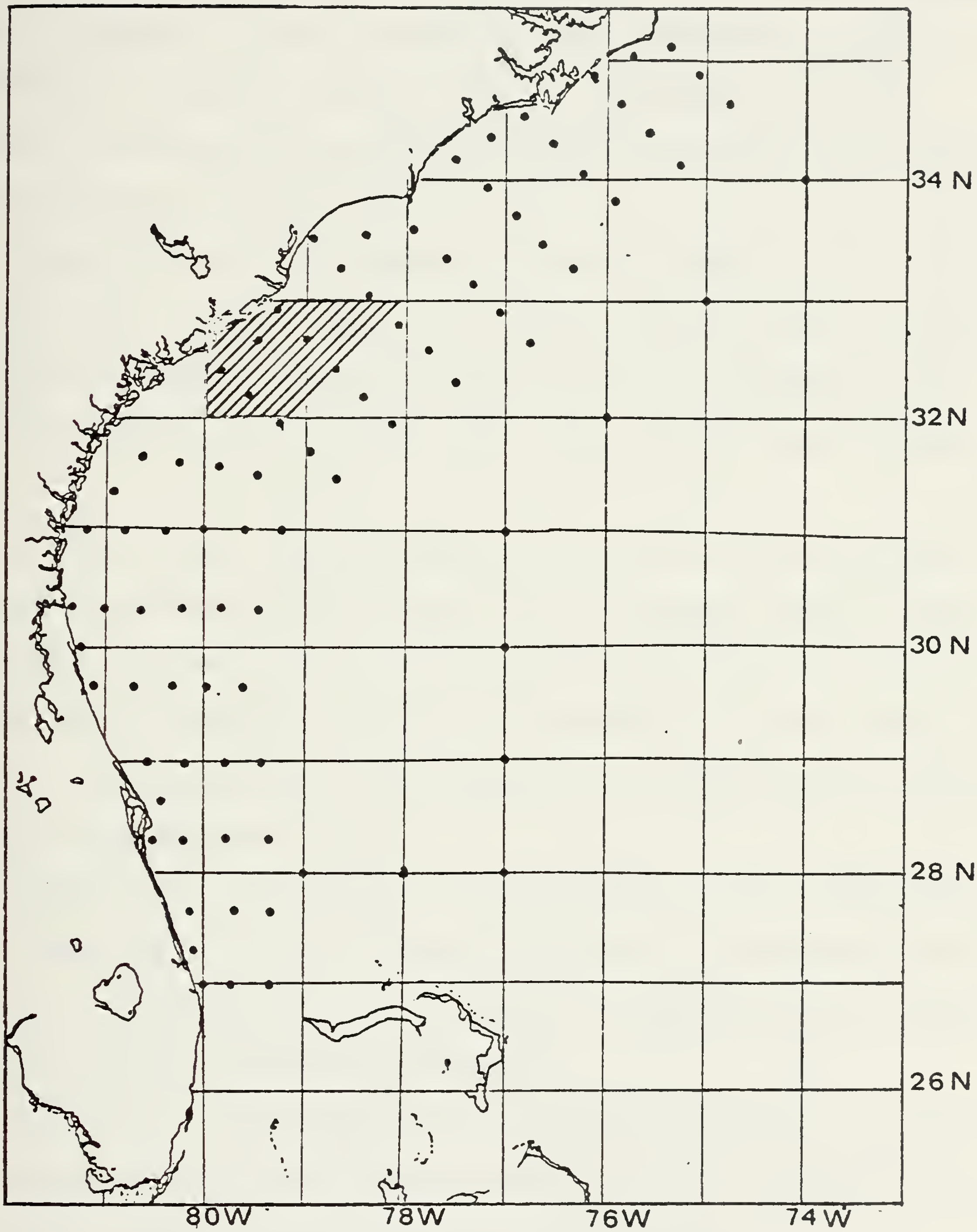

Figure 4

R/V GILL Station Plan
Cross-hatched Region is Area of Present Study

(From Kuroda and Marland, 1973)

temperatures at depth occurred gradually later with a direct depth relation (Kuroda and Marland, 1973). As an example, minimum temperature at 50 meters may occur in February whereas at 100 meters it occurs in March. The temperature at 200 meters at a point is nearly constant throughout the year. Table I, extracted from Kuroda and Marland (1973) summarizes the temperature distribution.

Isohalines are also shown to parallel the coastline (Kuroda and Marland, 1973). Near shore, surface salinities exhibited a seasonal change whereas offshore salinities showed little seasonal effect and remained near $36^{\circ}/_{\circ\circ}$ (Kuroda and Marland, 1973).

Near the coast,the minimum salinities of $32^{\circ}/_{\circ\circ}$ were observed in January and February, and the maximum value of $35^{\circ}/_{\circ\circ}$ occurred in summer and autumn (Kuroda and Marland, 1973). Of particular interest are the near homogenous salinity values ($36^{\circ}/_{\circ\circ}$) observed throughout the area at a depth of 50 meters (Kuroda and Marland, 1973).

Ranges for salinities at greater depths (100 to 200 meters) were also small ($35^{\circ}/_{\circ\circ}$ to $36^{\circ}/_{\circ\circ}$) (Kuroda and Marland, 1973). Table II, also extracted from Kuroda and Marland, is a summary of the salinity variations observed.

Analysis of the Temperature-Salinity diagrams for the R/V GILL data by Kuroda and Marland revealed the presence of four different types of water masses in the region.

The water mass present along the outer edge of the shelf is equivalent to the North Atlantic Central Water (NACW) as

TABLE I

TEMPERATURE (°C) IN THE WESTERN NORTH ATLANTIC

PERIOD \ DEPTH	0 METERS	10 METERS	50 METERS	100 METERS	200 METERS
JAN. - FEB.	10-23 (12)	11-24	18-24	14-24	12-21
FEB. - MARCH	12-24	12-24	16-24	12-24	9-20
APRIL - MAY	19-26	19-26	16-26	13-24	10-20
JUNE - JULY	25-29 (27)	24-28	18-27	15-25	11-20
JULY - AUG.	27-29	27-29	19-28	14-26	9-21
AUG. - SEPT.	25-29 (27-28)	25-29 (27-28)	20-28	11-26	9-20
NOV. - DEC.	13-26	13-26	21-26	17-26	9-20

TABLE II

SALINITY (°/oo) IN THE WESTERN NORTH ATLANTIC

PERIOD \ DEPTH	0 METERS	10 METERS	50 METERS	100 METERS	200 METERS
JAN. - FEB.	32-36	32-36	36-36.5	36	35-36
FEB. - MARCH	33-36	34-36	36-36.5	35-36	35-36
APRIL - MAY	34-36	34-36	36	35-36	35-36
JUNE - JULY	34-36	34-36	36	35-36	35-36
JULY - AUG.	34-36	35-36	36	35-36	35-36
AUG. - SEPT.	35-36	35-36	36	35-36	35-36
NOV. - DEC.	35-36	35-36	36	35-36	35-36

described by Stommel (1965) (Kuroda and Marland, 1973). This type exhibited the highest temperature and salinities observed. The water temperature above 100-200 meters showed large seasonal change but relative constancy below this depth (Kuroda and Marland, 1973).

A type of water labelled "mixing water" by Kuroda and Marland (1973), exhibited very similar properties to the NACW previously described but temperatures were approximately 5°c lower in winter and autumn. The salinities observed above 100 meters had almost identical values as the first type while at 200 meters there was a decrease of about .4°/₀₀ (Kuroda and Marland, 1973). The third water mass, described as shelf water, was nearer shore. Salinities between 34.5°/₀₀ and 36°/₀₀ were characteristic and exhibited much seasonal change (Kuroda and Marland, 1973).

A fourth water mass was identified as "coastal water" and occurred very near the shore. This water mass exhibited large seasonal changes of both temperature and salinity (Kuroda and Marland, 1973). Convenience in analysis of regional conditions was the primary purpose of Kuroda and Marland's classification. Figure 5 is a generalized map of the distribution of these water masses, extracted from Kuroda and Marland (1973).

The suite of water masses described extend out to approximately 100 miles offshore, just inside the western edge of the Gulf Stream. Each mass is continually interacting with the others resulting in modification to the original character.

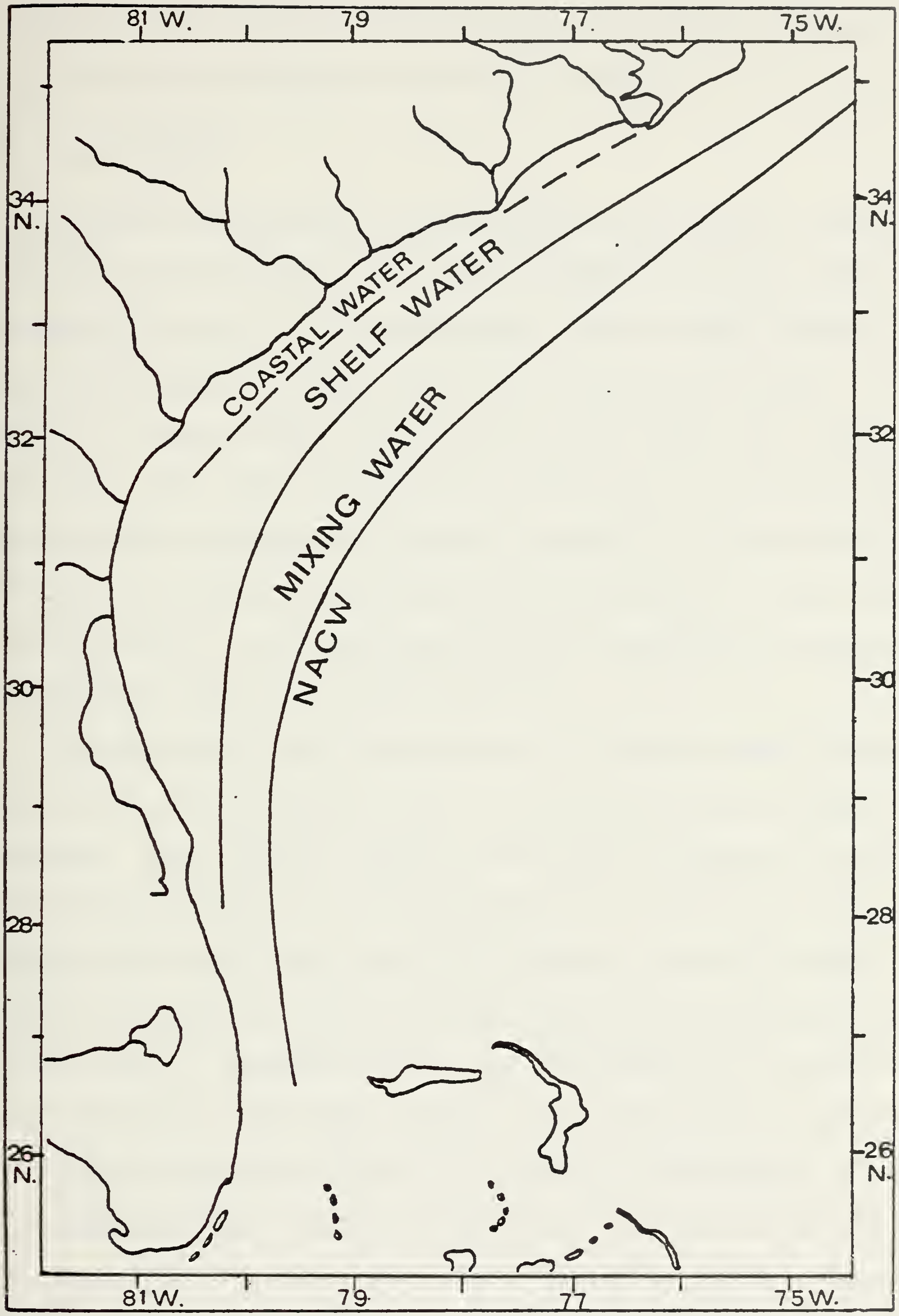

Figure 5
Water Mass Distribution

Seasonal distributions of these masses and their movement is also described by Kuroda and Marland (1973).

B. DATA SOURCE

The data utilized in this analysis was obtained from the National Oceanographic Data Center (NODC) in October 1978. A magnetic tape of all oceanographic station data (Nansen cast and STD stations) for Marsden square 116 was furnished. A total of approximately 300 stations were within the area of interest. The data consisted of temperature, salinity and sound speed (computed by Wilson's equation) for each station. Additional information included: position, date, time, ship identification and other meteorological chemical and optical information wherever it was measured.

The magnetic tape furnished was in standard NODC format: nine-track, 800 bits per inch, 80 character, full-blocked records. Each station record consisted of a master record containing positional and identification data and a detail record containing the salinities, temperatures and sound speeds obtained for each standard depth (to the maximum depth of the cast). Standard depths for oceanographic observations are a matter of agreement within the oceanographic community. NODC files contain records (for depths to 400 meters) at the following standard depths (in meters): 0, 10, 20, 30, 50, 75, 100, 125, 150, 200, 250, 300, 400 (NODC, 1974). Where observations do not conform to the standard depths, interpolations are made utilizing a 3-point Lagrange interpolation

equation (NODC, 1974). Wherever salinity, temperature and depth data are present and the values are not doubtful, sound speeds are computed (NODC, 1974).

C. TECHNIQUES FOR SUMMARIZING SOUND SPEED DATA

The objectives were to examine and summarize the historical sound speed data available and evaluate its suitability for determination of correctors for echo soundings in the study area.

Temperature and salinity variability was also examined and its relation to sound speed variability noted. Several methods for summarizing the sound speed variability in an oceanic region have been devised by other researchers.

Russell (1975) developed a method for selecting typical sound speed profiles from oceanographic station data with application to interpretations of acoustic system performance. The data was abstracted in groups representing estimates of natural temporal and spatial populations. The study utilized NODC data as well as available XBT data. In this method, the ocean regions represented natural oceanographic domains. Each domain exhibited similar physical properties and current regimes.

Russell's (1975) study is limited in application. The primary reason for this is difficulty in accessing data bases other than those maintained by NODC. The study is further limited because it is directed to deep water horizontal propagation.

The profiles generated are useful as pilot information but the variability of these profiles within a region is not defined with the precision required for application to the echo sounding problem.

Audet and Vega (1974) developed a similar technique to that of Russell (1975). The data utilized was exclusively the NODC Oceanographic Station File.

In this technique, all profiles for a region are examined. Three profiles which exhibit the smallest variations relative to all other profiles are selected, the profile exhibiting the least variability being selected as the model profile. The other two profiles are compared to the model and the standard deviation computed between the model and these two representative profiles. This study is of interest due to the methods employed. However, the study was primarily concerned with deeper oceanic regions and application to variable continental shelf areas is inappropriate.

The HIDAT program in use by the U.S. Naval Fleet Numerical Weather Central is used to characterize sound speed conditions in ocean regions for forecasting performance of military acoustic systems.

Output for the HIDAT program is a month-by-month summary showing the temperature and salinity profile which is found to be representative of a region. The representative profile is an actual observed profile which shows the smallest standard deviation from all other profiles in the region.

Standard deviations at standard depths are computed and represent variance of the representative profile from the four most similar profiles in the area.

The smallest region for which HIDAT information can be generated is a one-degree latitude-longitude square.

The data base for HIDAT includes all NODC data as well as extensive XBT data from other sources. This results in much greater data density for an area. The HIDAT program is similar to the system suggested by Audet and Vega (1974).

All three prior techniques were developed in response to specific operational requirements. None of the three was designed appropriately for echo sounding correction. Each technique was concerned with selection of an actual profile as the representative profile in a region. This is an important design criteria in that it permits identification of the sonic layer depth. Identification of the sonic layer depth is important for horizontal acoustic propagation. This was the application for each of the three studies examined.

The selection of an actual observed profile is unnecessary for vertical echo sounding because minor changes in location of the sonic layer depth have little effect on mean vertical sound speeds. Further research and adaptation of these programs to the echo sounding problem might result in useful techniques.

D. COMPUTER PROCESSING

All computer processing in this analysis was accomplished utilizing the IBM 360/67 computer system of the W. R. Church Computer Center at the U.S. Naval Postgraduate School (NPS).

In addition to the programs written to perform the required analysis of NODC data, several existing programs for abstracting and plotting NODC data were employed. These programs were written by Dr. R. G. Paquette of the Department of Oceanography, Naval Postgraduate School. All programs were written in Fortran and complete listings and documentation are contained in Appendix 1.

Initially, all station records from the NODC unlabelled magnetic tape were transferred to a standard NPS labelled tape. This resulted in a faster retrieval time and fewer errors in reading the tapes. Although the NODC tapes were compatible with tape drives at the NPS computer center, reading problems may occur whenever magnetic tapes are read on a drive different from the machine on which they are created. Transfer to the NPS standard labelled tape eliminated the errors associated with this problem.

A computer listing of all NODC station header records for Marsden Square 116 was made. This listing was produced using program NODCDUM, written by Dr. R. G. Paquette of the Naval Postgraduate School. These records were examined to locate all stations within the study area. The stations of interest were all located within two adjacent blocks of record numbers. This resulted from the format of NODC data

tapes. Within a Marsden Square, further blocking or subdivision of records is made by one-degree latitude and longitude squares.

A complete listing of the header and detail record for each station within the study area was then produced on a month-by-month basis. As an example, all stations observed in a particular month (all years) were listed together for ease in indexing. The program used to make this listing was NODCRD, also written by Dr. Paquette. The record produced was a hard copy printout of all stations observed each month. The information in this listing consisted of both the header record (position, date, year, country and ship identification and NODC index numbers) and the detail record giving the type of observation (Nansen or STD), temperature, salinity, density (σ_t), oxygen content and sound speed at each standard depth to the limit of observation. This listing served a reference and index function throughout the study. A sample record for one station is shown in figure 6.

Four punched data cards were produced for each station. The first card was produced using NODPUNA. It contained latitude, longitude, NODC reference number, month in which the observation was made, and the sound speeds for each depth to the limit of observation or 400 meters, whichever was shallower. Speeds were recorded to tenths of meters per second. The second card contained the same positional and index information but observed temperatures were abstracted to two decimal places instead of sound speeds. This card was

CTY	SHP	LAT(N)	LONGITUD	MSQ	YR	MO	DY	HR	CRND	STANO	DPTH	SDTH	NOBS	ID	TYP	N	NN	NREC
31	PE	32-039	079-040	116	66	03	22	140	018	003		3		07820004	1	14	65	88620

DEPTH	TEMPERATURE	SALINITY	SIGNA-T	OXYGEN	SV	TYPE
0000	22.95	36.26	24.92	4.94	1531.3	6
0000	22.95	36.260	24.92	4.94	1531.3	3
0010	22.92	36.26	24.93	4.99	1531.4	6
0010	22.92	36.257	24.93	4.99	1531.4	3
0020	22.26	36.26	25.12	5.10	1529.9	6
0020	22.26	36.262	25.12	5.10	1529.9	3
0030	21.55	36.27	25.33	5.20	1528.2	6
0030	21.55	36.274	25.33	5.20	1528.2	3
0040	20.68	36.246	25.55	5.34	1526.1	3
0050	20.43	36.25	25.62	5.21	1525.6	6
0050	20.43	36.247	25.62	5.21	1525.6	3
0060	20.06	36.254	25.72	5.08	1524.7	3
0075	19.84	36.47	25.95	4.79	1524.7	6
0080	19.66	36.492	26.01	4.00	1524.3	3
0100	18.36	36.28	26.18	4.59	1520.7	6
0100	18.36	36.280	26.18	4.59	1520.7	3
0125	18.09	36.258	26.23	4.69	1520.2	3
0125	18.03	36.26	26.24	4.69	1520.1	6
0140	17.87	36.247	26.28	4.70	1519.9	3
0150	17.85	36.22	26.26	4.58	1520.0	6
0160	16.94	36.198	26.46	4.35	1517.4	3
0180	12.48	35.608	26.99	3.53	1502.8	3
0190	09.43	35.166	27.20	3.02	1491.8	3
0200	09.37	35.16	27.20	3.02	1491.5	6
0210	08.56	35.048	27.25	3.01	1488.7	3
0230	08.59	35.046	27.24	2.99	1489.1	3
0250	08.59	35.05	27.24	2.97	1489.3	6
0250	08.59	35.046	27.24	2.96	1489.5	3
0270	08.56	35.055	27.25	2.99	1489.7	3
0290	08.27	35.020	27.27	3.05	1488.9	3
0300	08.26	35.02	27.27	3.05	1488.9	6
0310	08.19	35.009	27.27	2.99	1488.9	3

Figure 6

Sample NODCRD Output
For one Oceanographic Station
Type 3 indicates interpolated data
Type 6 indicates observed data

produced using NODPUNC. The third data card was also similar but salinities to two decimal places were abstracted for each standard depth. NODPUNB was used to produce these cards. The fourth data card was produced as input to a station plotting program, CHARTPLT. This card contained latitude and longitude of the station. The card was produced using NODPUN. This additional card with positional information was produced in order to avoid programming changes to accomodate a new format. Samples of all four cards are shown in figure 7.

The programs used to produce the first 3 cards (NODPUNA, NODPUNB, and NODPUNC) differed only in the record abstracted (speed, temperature or salinity). The temperature, salinity and sound velocity cards were used as input to the statistical program written to summarize the data.

VELDAT was the basic statistical program written to summarize the sound speed data. Slight modifications to this program, particularly in input format, resulted in programs SALDAT and TEMDAT. All three have the same basic functions, and produce the same results. VELDAT was used to analyze sound speed data, SALDAT for salinity data and TEMDAT for temperatures.

Input to these programs were the appropriate data cards previously described and shown in figure 7.

VELDAT output consisted of the mean sound speed profile (at standard depths), the standard deviation at each standard depth, number of samples included in the calculation and the

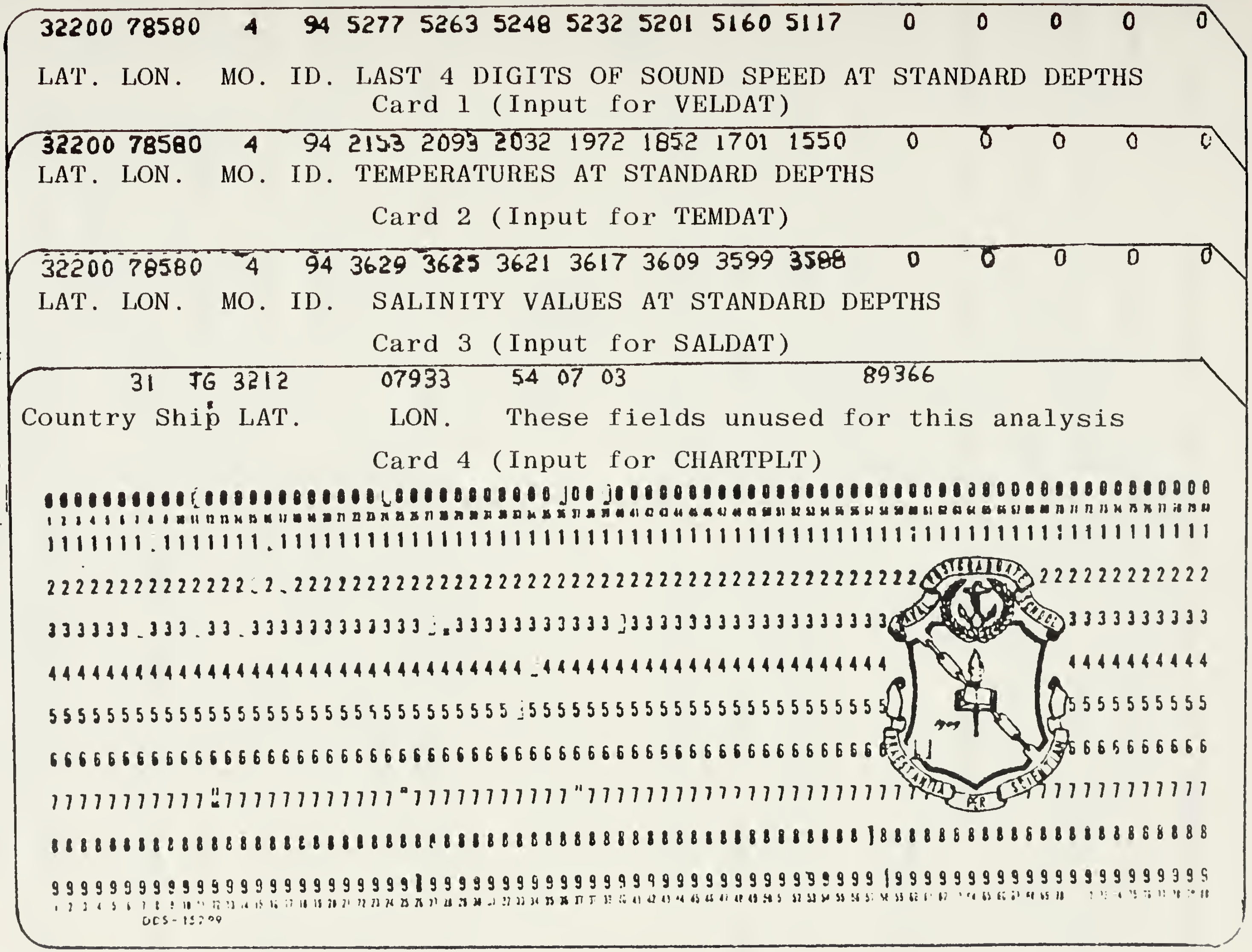
32200 78580 4 94 5277 5263 5248 5232 5201 5160 5117 0 0 0 0 0
LAT. LON. MO. ID. LAST 4 DIGITS OF SOUND SPEED AT STANDARD DEPTHS
Card 1 (Input for VELDAT)
32200 78580 4 94 2153 2093 2032 1972 1852 1701 1550 0 0 0 0 0
LAT. LON. MO. ID. TEMPERATURES AT STANDARD DEPTHS
Card 2 (Input for TEMDAT)
32200 78580 4 94 3629 3625 3621 3617 3609 3599 3588 0 0 0 0 0
LAT. LON. MO. ID. SALINITY VALUES AT STANDARD DEPTHS
Card 3 (Input for SALDAT)
31 TG 3212 07933 54 07 03 89366
Country Ship LAT. LON. These fields unused for this analysis
Card 4 (Input for CHARTPLT)

Figure 7

location and values of maximum and minimum sound speeds. Temperature and salinity data were similarly analyzed.

The values for sound speeds at each standard depth for each station in the study area were input into VELDAT, grouped by season. As an example, all stations observed in January, February or March are examined together. Other seasons were defined as: Spring (April, May, June); Summer (July, August, September), and Autumn (October, November, December). This seasonal breakdown followed the practice of other researchers in the area (Kuroda and Marland, 1973).

Initially, sound speeds for each standard depth for all stations in the area were averaged and the sample mean computed. The following equation represents the computation made in VELDAT:

$$\overline{SV}_d = \frac{\sum_{i=1}^{N} SV_{d_i}}{N} \qquad (5)$$

$\overline{SV}_d$ was the mean sound speed at a particular standard depth (d) over the entire area. $\sum SV_{d_i}$ was the sum of all sound speed values at a particular standard depth, and N was the number of sound speed values found for a particular standard depth. Where no value was found for a particular depth or a zero value was encountered, this sample was not included and N was not incremented.

A sample standard deviation was computed for sound speeds at each standard depth utilizing the following equation:

$$S_{SVd} = \left[\frac{\sum (SV_{d_i} - \overline{SV}_d)^2}{N-1} \right]^{\frac{1}{2}} \qquad (6)$$

S_{SVd} is the standard deviation of the sound speeds at a particular standard depth. $\overline{SV}_d$ was the mean sound speed computed for the particular depth in question and N was the number of samples. The same procedure for dealing with blank or zero values was used in this computation as in the computation for mean sound speed. TEMDAT and SALDAT utilized the same equations for producing mean temperatues and salinities as well as standard deviations. Appendix 1 documentation includes input or data format required, variable specifications for different regions and modes of operation possible.

The procedure utilized to compute mean sound speeds and standard deviations at standard depths was suggested by the fact that present NOS practice dictates use of the "summation of layers" method for determination of sound speed corrections at depth. This method has been previously described in section I.C. of this thesis.

E. PROCEDURE

Sound speed data cards for all stations were produced and sorted by month. Variability of sound speeds over the entire area on a monthly basis was examined initially. Lack of substantial numbers of observations during any particular month precluded use of this technique for drawing meaningful conclusions.

Three month seasonal groupings were then combined and analyzed using VELDAT. The program output exhibited a larger variability than could be tolerated under the accuracy requirements stated. The question of applicability of historical data would have been quickly resolved had the variabilities over the entire area been small enough to match the stated accuracy requirements. However, this was not the case, the varibility was too great; thus leading to a form of spatial subdivision.

The locations of stations exhibiting the maximum and minimum sound speed values revealed that grouping by area might reduce the observed standard deviations. These results, examined in view of the variation of physical properties of the waters (Kuroda and Marland, 1973), suggested a sub-division of the area into two regions. Since sound speed values should be similar for waters with similar physical properties, the objective of the sub-division was to separate the area into two natural populations of sound speed profiles. This method followed the procedure cited by Russell (1975), although his study was concerned with sub-division on a much larger scale.

The division was made along a northeast - southwest trending line approximately paralleling the 18 meter depth contour. The near-shore region resulting from this division was expected to exhibit much greater variations in sound speeds and hence a greater standard deviation. The offshore region was expected to show smaller variations of sound speed values. Figure 8 is a map of the area showing the division made. Sound speed

Regional Division of Study Area

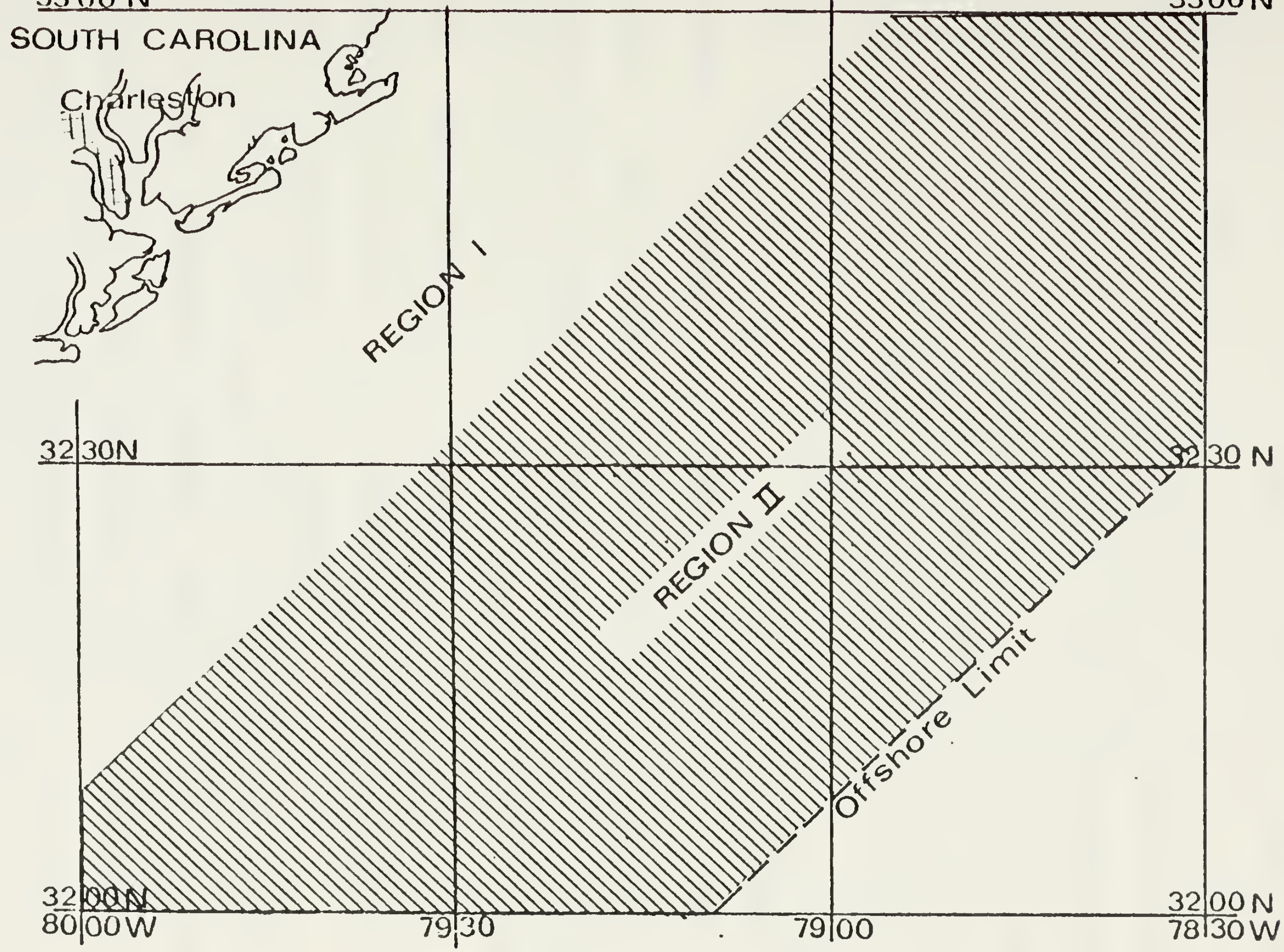

Figure 8

analysis was then achieved for each of the regions using VELDAT and the seasonal breakdown previously cited. A similar procedure was carried out in order to examine temperature and salinity variability in the region. TEMDAT and SALDAT were employed to this purpose.

Graphic profiles were produced from the VELDAT output showing the mean sound speed profile, and the maximum and minimum profiles for the offshore region. Profiles were produced for each season. Salinity and temperature profiles were also produced on a seasonal basis. Profiles for the inshore region were not produced due to the sparseness of data in the region.

Output from the statistical programs (VELDAT, TEMDAT, SALDAT) are included in Appendix 2. Seasonal Profiles of sound speed, temperature, and salinity are also included in Appendix 2.

Representative monthly temperature and salinity profiles were requested from HIDAT at Fleet Numerical Weather Central. The HIDAT output was used for comparison purposes with output from TEMDAT and SALDAT. The comparison was employed to validate results obtained in this analysis.

HIDAT salinity and temperature profiles were requested for the entire one-degree square, extending from latitude 32°N to latitude 33°N and from longitude 79°W to longitude 80°W. Typical values for salinity and temperature at standard depths for each month were the output for HIDAT. Data for the entire square was requested due to the fact that a one-degree square is the smallest subdivision possible with the HIDAT system. Seasonal averages of salinities and temperatures for standard

depths to 100 meters were made of the HIDAT typical profiles in order to compare the results with SALDAT and TEMPDAT output. The results of the comparison are summarized in Table III.

	WINTER				SPRING				SUMMER				FALL			
Depth (M)	TEMDAT Mean Temp. Deg-C	HIDAT Average Temp. Deg-C	SALDAT Mean Sal. (ppt)	HIDAT Average Sal. (ppt)	TEMDAT Mean Temp. (Deg-C)	HIDAT Average Temp. (Deg-C)	SALDAT Mean Sal. (ppt)	HIDAT Average Sal. (ppt)	TEMDAT Mean Temp. (Deg-C)	HIDAT Average Temp. (Deg-C)	SALDAT Mean Sal. (ppt)	HIDAT Average Sal. (ppt)	TEMDAT Mean Temp. (Deg-C)	HIDAT Average Temp. (Deg-C)	SALDAT Mean Sal. (ppt)	HIDAT Average Sal. (ppt)
0	19.24	20.65	36.29	36.31	20.63	22.22	35.72	36.21	27.74	27.44	35.60	35.11	24.09	25.13	36.25	36.21
10	19.05	20.65	36.28	36.30	20.49	22.20	35.86	36.24	27.32	27.21	35.68	35.59	24.03	25.11	36.25	36.24
20	19.14	20.60	36.24	36.30	20.15	21.76	36.14	36.24	26.16	26.82	35.92	35.98	23.90	25.01	36.26	36.24
30	19.35	20.45	36.28	36.30	19.90	20.16	36.22	36.24	24.23	23.11	36.12	36.32	24.32	24.78	36.26	36.25
50	19.01	19.50	36.29	36.26	18.90	19.67	36.29	36.35	22.31	21.44	36.18	36.24	24.73	24.46	36.34	36.25
75	18.26	****	36.27	****	17.81	****	36.28	****	19.69	****	36.09	****	23.29	****	36.35	****
80	****	18.14	****	36.19	****	18.87	****	36.35	****	18.85	****	36.21	****	23.19	****	36.19
100	17.46	16.72	36.24	36.08	16.25	17.48	36.19	36.30	16.94	17.43	35.87	36.29	21.17	19.48	36.36	36.18

TABLE III

Comparison of HIDAT Results with TEMDAT and SALDAT Results

III. RESULTS

VELDAT analysis of the inshore region (I) of the study area produced little in the way of usable results. Data density in this region was so sparse as to render the results statistically meaningless. Less than 50 stations (all months, all years) were observed in region I.

Results of the analysis of region I exhibited standard deviations in the range of 1.2 meters/sec to 8.6 meters per second, depending on the season. Information was confined to the upper 10 meters of the water column as there were no observations below this depth. Computations were based on a maximum of 16 samples for any one season. Table IV is a summary of VELDAT results for this region.

The results indicated for region I clearly show that lack of adequate samples of historical data in the form of archived STD and Nansen Cast observations precludes use of this method to obtain velocity correctors for echo sounding.

In-situ observations would have to be made of temperature, salinity and depth in this region in order to obtain velocity corrections. This result is important in itself since it identifies a region lacking in data.

Results of the analysis for region II are exhibited in appendix 2. A plot of all stations observed is included as appendix 3. Stations are plotted on a seasonal basis. The results produced indicated that there was little information with which to work for depths greater than 100 meters.

TABLE IV

SUMMARY OF VELDAT RESULTS
REGION I

SEASON	DEPTH	MEAN SOUND SPEED	MAXIMUM SOUND SPEED	MINIMUM SOUND SPEED	STANDARD DEVIATION	NUMBER OF SAMPLES
WINTER	0 (SURFACE)	1503.3	1518.4	1498.0	7.5	6
	10	1504.6	1518.6	1500.3	7.0	6
SPRING	0	1520.6	1527.4	1513.8	4.1	12
	10	1519.4	1522.8	1513.1	2.8	8
SUMMER	0	1540.5	1543.3	1538.0	1.4	16
	10	1540.7	1543.0	1538.0	1.5	12
AUTUMN	0	1523.4	1532.2	1509.5	8.3	11
	10	1522.7	1532.3	1509.8	8.6	9
	(METERS)	(M/SEC)	(M/SEC)	(M/SEC)	(M/SEC)	

However, the major portion of region II exhibits depths in the range of 18 to 95 meters (exceptions along the shelf break noted).

Winter mean sound speeds computed ranged from 1521.5 m/s at the surface to 1517.9 m/s at a depth of 100 meters. Standard deviations of sound speeds ranged from 4.4 m/s (at 75 meters) to 5.7 m/s (at 100 meters).

Mean temperatures for the same period ranged from 19.24°c at the surface to 17.46°c at 100 meters. Standard deviations ranged from 1.89°c at the surface to a minimum of 1.53°c at 50 meters.

Mean salinities exhibited a spread that ranged from 36.29°/₀₀ at the surface to 36.24°/₀₀ at 100 meters with standard deviations showing a maximum spread of from .10°/₀₀ (surface) to .32°/₀₀ (20 meters).

Results for the spring showed less variability. Mean sound speeds for the spring ranged from 1524 m/s at the surface to 1514.4 m/s at 100 meters. Standard deviations were in the range of 4.2 m/s at the surface to 2.6 m/s at 75 meters.

Mean temperatures for this season ranged from 20.63°C at the surface to 16.25°C at 100 meters. Standard deviations were in the range of 1.75°c at 10 meters to .87°c at 75 meters.

Mean salinities ranged from 35.72°/₀₀ at the surface to 36.19°/₀₀ at 100 meters. Standard deviations of .77°/₀₀ (surface) to .15°/₀₀ (50 meters) were observed.

The summer months exhibited the smallest variation in sound speeds only in the upper 10 meters.

Summer mean sound speeds ranged from 1541.7 m/s at the surface to 1515.6 m/s at 100 meters. Standard deviations ranged from 1.7 m/s (surface) to 11.1 m/s (100 meters).

Mean temperatures ranged from 27.74°c at the surface to 16.94°c at 100 meters. Variability as exhibited by standard deviations ranged from .78°c (surface) to 3.58°c (100 meters).

Mean salinities ranged from 35.60°/oo at the surface to a maximum of 36.18°/oo (50 meters). Standard deviations ranging from .53°/oo (surface) to .21°/oo (50 meters) were noted.

Autumn mean sound speeds ranged from 1533.9 m/s at the surface to 1527.8 m/s at 100 meters. Standard deviations ranging from 3.3 m/s (30 meters) to 13.8 m/s (100 meters) were computed.

Mean temperatures for any particular depth during this period ranged between 24.73°c (50 meters) and 21.17°c (100 meters). Standard deviations were in the range of 1.2°c (50 meters) to 4.91°c (100 meters).

Mean salinities ranged from 36.25°/oo at the surface to 36.36°/oo at 100 meters. Standard deviations for any depth fell in the range of .10°/oo (20 meters) to .34°/oo 100 meters).

The results indicate that sound speeds are least variable during the spring. This corresponds to the period of when temperatures throughout the column are least variable.

Near surface summer temperatures (1-10 meters) showed the least variation for any particular period or depth but variation increased substantially below 10 meters depth.

Salinities were least variable during the winter and fall, but standard deviations of salinity were always less than 1°/₀₀. If a two sigma variation were examined, only two computed salinity standard deviations would be in excess of 1°/₀₀ (surface and 10 meter depth during the spring).

Examination of the physical properties and seasonal nature of waters in this region based on the R/V GILL data as presented by Kuroda and Marland (1973) shows that these results are as expected.

Table V is a summary of the Region II standard deviations of sound speed, temperature and salinity on a seasonal basis abstracted from the results exhibited in appendix 2.

The relation between temperature and sound speed is already well-documented. Sound speeds calculated with Wilson's (1960) equation are more dependent on temperature than on salinity and pressure effects combined. Therefore it is reasonable to expect the largest variation of sound speed to occur when temperature variation is a maximum. A 1°c temperature increase will produce a corresponding increase in sound speed of 4.5 m/s. Likewise, a 1°/₀₀ salinity increase produces 1.3 m/s increase in sound speed and 100 meters depth increase will produce a 1.4 m/sec sound speed increase (Ingham, 1975).

The results obtained, indicate that sound speed variability is much more sensitive to temperature variation than to salinity variation. In addition, the results indicate that the greatest variation in sound speeds does not occur at the surface but at some depth below it, corresponding to the depth of greatest

TABLE V

VARIABILITY (ONE-SIGMA) OF SOUND SPEED, TEMPERATURE, AND SALINITY

	WINTER			SPRING			SUMMER			AUTUMN		
DEPTH (M)	SOUND SPEED (M/SEC)	TEMP. (°C)	SALINITY (ppt)	SOUND SPEED (M/SEC	TEMP. (°C)	SALINITY (ppt)	SOUND SPEED (M/SEC)	TEMP. (°C)	SALINITY (ppt)	SOUND SPEED (M/SEC)	TEMP. (°C)	SALINITY (ppt)
0	5.4	1.85	0.10	4.2	1.72	0.77	1.7	0.78	0.53	4.5	1.81	0.17
10	5.3	1.84	0.10	4.1	1.75	0.61	1.8	0.84	0.48	4.4	1.78	0.13
20	4.9	1.70	0.32	3.6	1.71	0.23	3.3	1.39	0.32	4.5	1.84	0.10
30	4.9	1.69	0.12	4.1	1.56	0.21	5.4	2.19	0.21	3.3	1.35	0.12
50	4.5	1.53	0.14	2.8	1.03	0.15	6.0	2.31	0.21	3.0	1.20	0.18
75	4.4	1.69	0.14	2.6	0.87	0.18	7.0	2.45	0.38	7.5	2.84	0.21
100	5.7	1.81	0.20	3.2	0.97	0.29	11.1	3.58	0.50	13.8	4.91	0.34

temperature change. The depth of greatest temperature change varies between 75 and 100 meters depending on the season. This boundary layer between the zone responding to climatic and mixing effect and a lower zone of constant temperature decrease is usually noted as the thermocline depth. However the thermocline in this region is not well-defined. The motion of this boundary layer in the vertical leads to the large variability of temperatures observed at depths between 75 and 100 meters.

The comparison of results achieved during this study with the averaged HIDAT results revealed that, in general, HIDAT temperature averages were 1°c to 2°c higher than TEMDAT mean temperatures. HIDAT salinities agree with SALDAT mean salinities to within .5°/₀₀ for almost all cases.

The temperature variation noted is probably due to two factors:

1) The HIDAT routine used considerably more data in the form of XBT observations than the data base for TEMDAT contained.
2) The HIDAT data is more heavily weighted toward deeper (farther offshore) portions of the area. This is also the region of higher temperatures since isotherms parallel the coast and temperatures increase offshore. The "weighting" is due to the fact that XBT observations are not made in the shallow (200 meters near shore coastal regions as often as they are at depths greater than 200 meters).

The significance of the HIDAT comparison lies in the fact that it was an independent selection scheme used to check results obtained in this study.

IV. CONCLUSIONS

The results of the VELDAT analysis for region I were less than satisfactory. Low data density in this region precludes the determination of sound speed profiles with any statistical certainty. Therefore, the use of historical sound speed information for correction of echo soundings is precluded in this region.

In-situ measurement of temperature, salinity and depth or sound speed directly would have to be made in this region in order to correct echo soundings. Extrapolation of this result to other near shore regions on the east coast of the U.S. was not done. Nevertheless, a cursory examination of the number of stations occurring in the near shore region of Marsden Square 116, of which the study area is a portion, indicates that low data density in these regions will be a limiting factor.

Results of the analysis for the offshore region (II) allow several conclusions to be drawn.

NOS accuracy considerations require that mean sound speed be known to within ±4 m/sec. Considering the variability involved in making measurements of parameters from which sound speed is computed, it is the author's opinion that this requirement can logically be interpreted to include 95.5% of the observations or a variability of two standard deviations (2σ).

Table 5 shows the value in meters per second of a one-sigma variation at each standard depth computed using VELDAT for each season. This table also gives the value of a one sigma variation for salinity and temperature at each standard depth.

The results summarized in table 5 indicate that two standard deviations at any standard depth would exceed the required ±4 meter per second value for sound speed, with the exception of the upper 10 meters during the summer.

Further, during the winter, all values for one standard deviation exceed the ±4 m/sec requirement at all standard depths.

Other seasons show values of one-standard deviation which exceed the ±4 meter per second requirement for some portions of the water column.

The variability of the historical data exceeds the ±4 m/sec. criteria at the 2σ level, hence the question of whether or not historical information is adequate to develop echo sounding corrections is answered as negative for this region.

Data generated as a result of this study indicated that changes in present methods for in-situ determination of sound speeds would be possible.

The salinity data presented indicates that this is the least variable parameter affecting sound speed. Salinity data shows that the greatest standard deviation observed was .77°/₀₀, and this was atypical. Standard deviations for the most part were in the range of .1°/₀₀ to .5°/₀₀.

The analysis of Wilson's (1960) equation (Bivins, 1976) indicates that a natural variability of 3°/₀₀ in salinity could be tolerated if temperature measurements were made with sufficient accuracy (±.1°c).

If one sigma variation is in the range of .1°/₀₀ to .8°/₀₀, it is clear that if this were extrapolated to 2σ to include 95.5% of the values, the variability would not exceed 3°/₀₀. Therefore temperature observations alone, and historically determined salinities would appear to meet the stated accuracy requirements. Such temperature observations could be made with the XBT system, instead of the currently used Nansen bottles with reversing thermometers and STD probes with increased efficiency.

XBT's are presently available with resolution capabilities of .01°C in temperature and 0.9 meters in depth (McDowell, 1978). This increased resolution over previous devices results from improved recorder design (McDowell, 1978).

Accuracy limits of the XBT have been quoted as "less than .2°C error 95% of the time" (Naval Oceanographic Office, 1978). Accuracy of the depth measurements obtained by the XBT are stated as less than 5 meters (Naval Oceanographic Office, 1978).

It has been suggested that accuracy improvements in XBT measurements can be obtained by utilizing an improved "rate of fall equation" for the probe (McDowell, 1978). Improved factory selection of thermistors used in XBTs including calibration could also increase repeatability of the measurements. Further testing and definition of the accuracy that can be obtained utilizing the XBT would be desirable.

Finally, the data base used in this study indicated that near-shore data for the study area was sparse. This fact may be characteristic of NODC files for near-shore coastal regions. Further efforts to improve the NODC data base would result in an improved determination of variability in the region.

Investigation of the T-S relation in these regions may also prove useful for corrector determination. Where the T-S relation proves sufficiently constant, salinity determination may be made on the basis of water temperature alone. Further study will be necessary to define this relationship and determine applicable regions.

The results obtained during this analysis, while not statistically rigorous, present a general picture of sound speed variability within a shelf region and answer the question of applicability of historical information to the correction of echo soundings.

APPENDIX 1:

Computer Programs

```
C
C
C                ********** NODCDUM ***************
C
C
C              SOURCE:  DR. R.G.  PACQUETTE
C
C
C          THIS PROGRAM PROVIDES A LISTING OF HEADERS FOR NPS688 AND
C          ASSIGNS A SERIAL NUMBER IN COLUMNS 81-85
C
C
      DIMENSION HDR1(9),HDR4(9)
      REWIND 4
      NREC=0
      NHD=0
      WRITE(6,10)
   10 FORMAT(1X,'LISTING OF HEADERS FOR NODC TAPE: NPS433',44X,'NHD',3X,
     1'NREC')
   11 READ(4,100,END=300)HDR1,HDR2,HDR3,HDR4,HDR5,ITYP
  100 FORMAT(9A4,A1,A4,9A4,A2,I1)
      NREC=NREC+1
      IF(ITYP.NE.1)GO TO 11
      NHD=NHD+1
      WRITE(6,200)HDR1,HDR2,HDR3,HDR4,HDR5,ITYP,NHD,NREC
  200 FORMAT(1X,9A4,A1,A4,9A4,A2,I1,2X,I5,2X,I6)
      GO TO 11
  300 WRITE(6,400)
  400 FORMAT(//5X,'END OF FILE')
  999 STOP
      END
//GO.FT04F001 DD UNIT=3400-4,VOL=SER=NPS688,DISP=(OLD,KEEP),
//  DCB=(DEN=2,RECFM=FB,LRECL=80,BLKSIZE=3200),LABEL=(1,SL,,IN),
//  DSN=S2514.NDC2
```

```
C
C
C     NODCPUNCH 15 NOVEMBER 1978
C
C
C     THIS IS THE SECOND IN A SERIES OF THREE PROGRAMS WHICH WILL READ
C     SELECTED STATIONS FROM NODC TAPES(NODCRD MOD 3), PUNCH DATA CARDS
C     (NODCPUNCH), AND PLOT CROSS SECTIONS OF TEMPERATURE, SALINITY,
C     AND SIGMA-T(       ).
C
C
C     THIS PROGRAM READS SELECTED STATIONS FROM NODC TAPES,PRINTS THE
C     HEADER INFO,PUNCHES PARTIAL HEADER INFO(FOR STATION ID PURPOSES
C     ONLY), AND SELECTED STATION DATA. IF ORIGINAL STATION DATA IS
C     DESIRED SET NNUM=6, IF INTERPOLATED DATA IS DESIRED SET NNUM=3.
C
C     STATIONS ARE SELECTED AS IN NODCRD MOD 3:
C
C
C       A. BY DIRECT COMPARISON OF ONE FIELD(4 CHARACTERS MAX.) WITH
C          A TEST CONSTANT IN A-FORMAT.
C
C       B. SAME AS A. BUT WITH TWO FIELDS.
C
C       C. EITHER OR BOTH FIELDS IN A AND B MAY BE TESTED BY .GE.IX
C         OR .GE.IX.AND.LE.IY TYPE OF CRITERIA IN I-FORMAT.
C
C      CARD INPUT AND INSTRUCTIONS ARE CODED AS FOLLOWS.
C
C      CARD NO.1 : 80 BYTES OF FORMAT FOR READING CARD NO. 2. TYPICALLY
C      FOR ONE A-FORMAT COMPARISON FIELD,ONE BLANK,AND TWO INTEGERS:
C
C             (10A4,4X,I1,4X,I1,1X,A2,2X,A4,I1,1X,I4,I4,I6,5X)
C
C      CARD NO.2 : 40 BYTES OF VARIABLE FORMAT FOR READING THE TEST
C      VARIABLES IA AND IB FROM TAPE. ALWAYS SPECIFY TWO, EVEN THOUGH
C      YOU MAY  ONLY USE THE FIRST. IN COLUMN 45 (MD3) PUT A ZERO OR BLANK
C      IF ONE TEST VARIABLE IS TO BE USED; ANY OTHER NUMERAL WILL
C      INDICATE TWO TEST FIELDS. IN COLUMN 50 (MD1) A ZERO OR BLANK INDICATES
C      PURE CHARACTER RECOGNITION, A '1' INDICATES.GE. A SINGLE CONSTANT,
C      A '2' INDICATES .GE. TEST CONSTANT NO. 1,TC1, AND.LE. TC2;
C      TC1 AND TC2 ARE ENTERED IN COLUMNS 52-55 AND (IF APPROPRIATE) 56-59.
C                THE SECOND GROUP(SINGLE OR DOUBLE) OF TEST CONSTANTS
C      IS CODED SIMILARLY IN COLUMNS 60-69.COLUMN 60 (MD2) IS LIKE 50. TC3
C      AND (IF APPROPRIATE) TC4 ARE ENTERED IN 62-65 AND 66-69 RESPECTIVELY.
C      COLUMNS 70-75 CONTAIN AN INTEGER SPECIFYING THE NUMBER OF RECORDS
C      TO BE SKIPPED BEFORE PROCESSING; IF BLANK,NO SKIPS.
C
```

```
C         CARD NO. 3 : 40 BYTES FOR ENTERING A FORMAT FOR WRITING THE TEST
C         CONSTANTS,E.G.:
C
C               (1X,'TC1=',A3,', TC2=',A4,', TC3=',I4, TC4=',I4)
C
C        NOTE SOME MANIPULATIONS TO RECOVER THE MINUS SIGN IN TEMPERATURE
C        WHICH APPEARS AS AN 11 OR 12 PUNCH IN THE FOURTH DIGIT
C
C
C
      DIMENSION FMT1(10),FMT2(20),FMT(20),HDR1(19)
      INTEGER CC,YR,DAY,HR,STANO, DPTH,SDTH,TYP,T21,F1,D1,ZE,TC1,TC2,TC3,TC4
      DATA SGN1/' '/,SGN2/'-'/,F1/ZF0404040/,D1/ZD0404040/,
     1ZE/Z50404040/,SV1/'1'/,DOT/'.'/
C
      CALL REREAD
      REWIND 4
      WRITE(6,6)
    6 FORMAT(///)
C      N IS THE NUMBER OF HEADERS PRINTED,NN IS THE NUMBER OF HEADERS READ,
C      NPG IS THE COUNT OF NUMBER OF LINES PRINTED ON PAGE,NOPAGE IS THE
C      PAGE NUMBER,NREC IS THE NUMBER OF RECORDS READ
      NOPAGE=0
      N=0
      NN=0
      NPG=0
      NRD=0
      NNUM=6
C
C
C   READ FORMATS,ETC
C
      READ(5,400)FMT
  400 FORMAT(20A4)
      WRITE(6,401)FMT
  401 FORMAT(1X,'FMT=',20A4)
      READ(5,FMT)FMT1,MD3,MD1,TC1,TC2,MD2,TC3,TC4,ND
      WRITE(6,402)FMT1,MD1,MD2,ND,MD3
  402 FORMAT(1X,'FORMAT FOR READING TEST VARIABLES FROM TAPE,MODE1,MODE2
     1,THE NUMBER OF RECORDS TO BE SKIPPED,AND MODE3 ARE:',/1X,10A4,2I5,
     1I10,I5)
      READ(5,403)FMT2
  403 FORMAT(20A4)
      WRITE(6,FMT2)TC1,TC2,TC3,TC4
C      SKIP DIRECTLY TO PRINTING DATA, IF THERE IS NONE TO BE SKIPPED.
      K=0
      NREC=0
   77 IF(ND.EQ.0)GO TO 99
```

```
C
C       READ THE UNWANTED DATA
      K=1
    8 READ(4,9,END=200,ERR=190)
    9 FORMAT(79X,I1)
      IF(K.GE.ND) GO TO 99
      K=K+1
      GO TO 8
C       END OF UNWANTED DATA LOOP
C
   99 NREC=K
C
      NCPAGE=NOPAGE+1
      WRITE(6,50)
   50 FORMAT('1')
      WRITE(6,3) NOPAGE
    3 FORMAT(9X,'SELECTED HEADERS FOR BERING AND/OR CHUKCHI AND/OR BEAUF
     1ORT SEAS    PAGE   ',I3//)
      NPG=NPG+3
C         WRITE THE HEADING FOR THE HEADER RECORD DATA.
    5 WRITE(6,4)
    4 FORMAT(5X,'CTY SHP LAT(N)  LONGITUDE  YR MO DY  STANO           NRE
     1C'/)
C
      K=0
C
C       ----------BEGIN MAIN LOOP----------
C
   11 CONTINUE
C
C       HDR1 AND HDR2 CONTAIN ALL HEADER INFO EXCEPT TYPE WHICH IS THE
C       TEST VARIABLE TYP
C
      NREC=NREC+1
C
C       THE NEXT CARD IS ONLY TO BE USED FOR NPS688 IN THE ATLANTIC
C
      IF(NREC.GE.90865)GO TO 194
      READ(4,110,END=200,ERR=190)HDR1,HDR2,TYP
  110 FORMAT(19A4,A3,I1)
      IF(TYP.NE.1)GO TO 11
      NN=NN+1
      READ(99,FMT1)IA,IB
      CALL TEST(IANS,MD1,MD2,MD3,TC1,TC2,TC3,TC4,IA,IB)
C     A RETURN OF IANS=1 INDICATES TEST SATISFIED
      IF(IANS.NE.1)GO TO 11
      READ(99,10)CC,SH,LATD,LATM,LOND,LONM,LONM1,LONM2,MSQ,YR,MO,DAY,STA
     1NO
```

```
   10 FORMAT(3A2,2A3,3A1,A3,3A2,6X,A3)
   12 N=N+1
      NPG=NPG+2
C
C      WE EXAMINE LONM1 WHICH HAS AN OVERPUNCH FOR EAST LONGITUDES,
C      BECOMING D1,D2,ETC. AND DO INSTEAD OF F1,F2, AND F0.
C      WE START BY SUBTRACTING ZF0.  IF THE RESULT IS .GT. ZERO, THE
C      DIGIT HAD NO OVERPUNCH AND WE RECREATE THE DIGIT.  IF THE
C      RESULT IS .LT. ZERO, WE SUPPLY THE MINUS SIGN, FIND OUT IF IT WAS
C      A DIGIT .GT. ZERO BY A SIMILAR PROCEDURE, ETC.
C
      NB=LONM1-F1
      IF(NB.GE.0) GO TO 43
C      SIGN MUST BE NEGATIVE.
      SGN=SGN2
C      RECREATE ORIGINAL DIGIT AND SUBTRACT ZD0: THIS ALSO CONVERTS
C      A Z50 INTO A 10000000, A -0.
      NB=NB+F1-D1
      IF(NB.GE.0) GO TO 45
C      RECREATE DIGIT IF IT  WAS NOT AMONG 0 TO 9 AND PRINT IT UNCHANGED.
      NB=NB+D1
      GO TO 47
   43 SGN=SGN1
   45 NB=NB+F1
   47 WRITE(6,20)CC,SH,LATD,LATM,SGN,LOND,LONM,NB    ,LONM2,YR,MO,DAY,STA
     1NO,NREC
   20 FORMAT(/6X,A2,2X,A2,1X,A2,A3,4X,A1,A3,3A1,3X,3(A2,1X),1X,A3,10X,I6
     1)
      WRITE(7,21)CC,SH,LATD,LATM,SGN,LOND,LONM,NB    ,LONM2,YR,MO,DAY,STA
     1NO,NREC
   21 FORMAT(6X,A2,2X,A2,1X,A2,A3,4X,A1,A3,3A1,3X,3(A2,1X),1X,A3,10X,I6)
      WRITE(6,24)
   24 FORMAT(' ')
      NPG=NPG+2
C
   27 NREC=NREC+1
C      READ DATA
      READ(4,30,END=200,ERR=192) D,T1,T2,T21,    T22,S1,S2,ST1,ST2,
     1SV2,SV3,O1,O2,TYP
   30 FORMAT(T28,A4,1X,A2,3A1,A2,A3,A2,A2,T47,A3,A1,A1,A2,T80,I1)
      IF(TYP.NE.1)GO TO 31
      NN=NN+1
      IF(NPG.LE.70)GO TO 32
      NOPAGE=NOPAGE+1
      NPG=0
      WRITE(6,50)
      WRITE(6,3)NOPAGE
      WRITE(6,4)
```

```
   32 READ(99,FMT1)IA,IB
      CALL TEST(IANS,MD1,MD2,MD3,TC1,TC2,TC3,TC4,IA,IB)
      IF(IANS.NE.1)GO TO 11
      READ(99,10)CC,SH,LATD,LATM,LOND,LONM,LONM1,LONM2,MSQ,YR,MO,DAY,STA
     1NO
      GO TO 12
C      WE EXAMINE T21, WHICH HAS AN OVERPUNCH FOR A MINUS SIGN,
C      BECOMING D1,D2,ETC. AND DO INSTEAD OF F1,F2, AND F0.
C      WE START BY SUBTRACTING ZF0.  IF THE RESULT IS .GT. ZERO, THE
C      DIGIT HAD NO OVERPUNCH AND WE RECREATE THE DIGIT.  IF THE
C      RESULT IS .LT. ZERO, WE SUPPLY THE MINUS SIGN, FIND OUT IF IT WAS
C      A DIGIT .GT. ZERO BY A SIMILAR PROCEDURE, ETC.
   31 IF(TYP.NE.NNUM)GO TO 27
      NB=T21-F1
      IF(NB.GE.0) GO TO 33
C      SIGN MUST BE NEGATIVE.
      SGN=SGN2
C      RECREATE ORIGINAL DIGIT AND SUBTRACT ZD0; THIS ALSO CONVERTS
C      A Z50 INTO A 10000000, A -0.
      NB=NB+F1-D1
      IF(NB.GE.0) GO TO 35
C      RECREATE DIGIT IF IT  WAS NOT AMONG 0 TO 9 AND PRINT IT UNCHANGED.
      NB=NB+D1
      GO TO 37
   33 SGN=SGN1
   35 NB=NB+F1
   37 WRITE(6,95) D,SGN,T1,DOT,T2,NB,T22,S1,DOT,S2,ST1,DOT,ST2,O1,DOT,
     1O2,SV1,SV2,DOT,SV3,TYP
      WRITE(7,95) D,SGN,T1,DOT,T2,NB,T22,S1,DOT,S2,ST1,DOT,ST2,O1,DOT,
     1O2,SV1,SV2,DOT,SV3,TYP
   95 FORMAT(T9,A4,T18,A1,A2,4A1,T30,A2,A1,A3,T39,A2,A1,A2,T49,A1,A1,
     1A2,T57,A1,A3,A1,A1,T66,I1)
   90 NPG=NPG+1
      GO TO 27
C      --------END OF DATA-READ LOOP
C
C      ----------END OF MAIN LOOP
C
  190 IF(K.EQ.0) GO TO 192
      WRITE(6,191) K,CC,SH,LATD,LATM,LOND,LONM,ID1,ID2,TYP
  191 FORMAT(//5X,'READ ERROR IN SKIP LOOP: CONTINUE.  K= ',I6/)
      K=K+1
      GO TO 8
  192 WRITE(6,193)NREC
  193 FORMAT(//5X,'READ ERROR IN DATA-READ LOOP; CONTINUE.  NREC= ',I6/)
      NREC=NREC+1
      GO TO 27
  194 WRITE(6,195)
```

```
  195 FORMAT(//5X,' END OF BERING SEA DATA')
      GO TO 999
  200 WRITE(6,205)
  205 FORMAT(//5X,'END OF FILE')
      GO TO 999
  999 STOP
      END
C
C      SUBROUTINE TEST
C      DOES THE TESTING FOR NODCRD MOD. 3
C
      SUBROUTINE TEST(IANS,MD1,MD2,MD3,TC1,TC2,TC3,TC4,IA,IB)
C
C      TEST THE FIRST FIELD
C
      INTEGER TC1,TC2,TC3,TC4
      IF(MD1-1)20,40,60
   20 IF(IA.EQ.TC1)GO TO 30
      IANS=0
      GO TO 999
   30 IANS=1
      IF(MD3.EQ.0)GO TO 999
      GO TO 100
C
   40 IF(IA.GE.TC1)GO TO 50
      IANS=0
      GO TO 999
C
   50 IANS=1
      IF(MD3.EQ.0)GO TO 999
      GO TO 100
   60 IF(IA.GE.TC1)GO TO 65
      IANS=0
      GO TO 999
   65 IF(IA.LE.TC2)GO TO 70
      IANS=0
      GO TO 999
   70 IANS=1
      IF(MD3.EQ.0)GO TO 999
C
C      MD3.NE.0: TEST A SECOND FIELD
C
  100 IF(MD2-1)120,140,160
  120 IF(IB.EQ.TC3)GO TO 999
      IANS=0
      GO TO 999
  140 IF(IB.GE.TC3)GO TO 999
      IANS=0
```

```
      GO TO 999
C
  160 IF(IB.GE.TC3)GO TO 165
      IANS=0
      GO TO 999
  165 IF(IB.LE.TC4)GO TO 999
      IANS=0
  999 RETURN
      END
//GO.FT04F001 DD UNIT=3400-4,VOL=SER=NPS688,DISP=(OLD,KEEP),
//   DCB=(DEN=2,RECFM=FB,LRECL=80,BLKSIZE=3200),LABEL=(1,SL,,IN),
//   DSN=S2514.NDC2
//GO.SYSIN  DD  *
(10A4,4X,I1,4X,I1,1X,I2,2X,I2,2X,I1,1X,A4,A4,I6,5X)
(20X,I2,I2,56X)                                      0    0 12             085682
(1X,'TC1=',I2,',TC2=',I2,',TC3=',A4,',TC4=',A4)
```

```
C     ***********************NODCRD,MOD.3*****************************
C
C     R.G. PAQUETTE, 11OCT 78
C
C     READS SELECTED STATIONS FROM NODC TAPE. THESE STATIONS MAY BE
C     SELECTED AS FOLLOWS:
C
C       A. BY DIRECT COMPARISON OF ONE FIELD(4 CHARACTERS MAX.) WITH
C          A TEST CONSTANT IN A-FORMAT.
C
C       B. SAME AS A. BUT WITH TWO FIELDS.
C
C       C. EITHER OR BOTH FIELDS IN A AND B MAY BE TESTED BY .GE.IX
C         OR .GE.IX.AND.LE.IY TYPE OF CRITERIA IN I-FORMAT.
C
C      CARD INPUT AND INSTRUCTIONS ARE CODED AS FOLLOWS.
C
C      CARD NO.1 : 80 BYTES OF FORMAT FOR READING CARD NO. 2. TYPICALLY
C      FOR ONE A-FORMAT COMPARISON FIELD,ONE BLANK,AND TWO INTEGERS:
C
C           (10A4,4X,I1,4X,I1,1X,A2,2X,A4,I1,1X,I4,I4,I6,5X)
C
C      CARD NO.2 : 40 BYTES OF VARIABLE FORMAT FOR READING THE TEST
C      VARIABLES IA AND IB FROM TAPE. ALWAYS SPECIFY TWO, EVEN THOUGH
C      YOU MAY  ONLY USE THE FIRST. IN COLUMN 45 (MD3) PUT A ZERO OR BLANK
C      IF ONE TEST VARIABLE IS TO BE USED; ANY OTHER NUMERAL WILL
C      INDICATE TWO TEST FIELDS. IN COLUMN 50 (MD1) A ZERO OR BLANK INDICATES
C      PURE CHARACTER RECOGNITION, A '1' INDICATES.GE. A SINGLE CONSTANT,
C      A '2' INDICATES .GE. TEST CONSTANT NO. 1,TC1, AND.LE. TC2;
C      TC1 AND TC2 ARE ENTERED IN COLUMNS 52-55 AND (IF APPROPRIATE) 56-59.
C                THE SECOND GROUP(SINGLE OR DOUBLE) OF TEST CONSTANTS
C      IS CODED SIMILARLY IN COLUMNS 60-69.COLUMN 60 (MD2) IS LIKE 50. TC3
C      AND (IF APPROPRIATE) TC4 ARE ENTERED IN 62-65 AND 66-69 RESPECTIVELY.
C      COLUMNS 70-75 CONTAIN AN INTEGER SPECIFYING THE NUMBER OF RECORDS
C      TO BE SKIPPED BEFORE PROCESSING; IF BLANK,NO SKIPS.
C
C      CARD NO. 3 : 40 BYTES FOR ENTERING A FORMAT FOR WRITING THE TEST
C      CONSTANTS,E.G.:
C
C          (1X,'TC1=',A3,', TC2=',A4,', TC3=',I4, TC4=',I4)
C
C     NOTE SOME MANIPULATIONS TO RECOVER THE MINUS SIGN IN TEMPERATURE
C     WHICH APPEARS AS AN 11 OR 12 PUNCH IN THE FOURTH DIGIT
C
C
C
      DIMENSION FMT1(10),FMT2(20),FMT(20),HDR1(19)
      INTEGER CC,YR,DAY,HR,STANO, DPTH,SDTH,TYP,T21,F1,D1,ZE,TC1,TC2,TC3,TC4
```

```
      DATA SGN1/' '/,SGN2/'-'/,F1/ZF0404040/,D1/ZC0404040/,
     1ZE/Z50404040/,SV1/'1'/,DOT/'.'/
C
      CALL REREAD
      REWIND 4
      WRITE(6,6)
    6 FORMAT(////)
C       N IS THE NUMBER OF HEADERS PRINTED,NN IS THE NUMBER OF HEADERS READ,
C       NPG IS THE COUNT OF NUMBER OF LINES PRINTED ON PAGE,NOPAGE IS THE
C       PAGE NUMBER,NREC IS THE NUMBER OF RECORDS READ
      NCPAGE=2
      N=0
      NN=0
      NPG=0
      NRD=0
C
C
C    READ FORMATS,ETC
C
      READ(5,400)FMT
  400 FORMAT(20A4)
      WRITE(6,401)FMT
  401 FORMAT(1X,'FMT=',20A4)
      READ(5,FMT)FMT1,MD3,MD1,TC1,TC2,MC2,TC3,TC4,ND
      WRITE(6,402)FMT1,MD1,MD2,ND,MD3
  402 FORMAT(1X,'FORMAT FOR READING TEST VARIABLES FROM TAPE,MODE1,MODE2
     1,THE NUMBER OF RECORDS TO BE SKIPPED,AND MODE3 ARE:',/1X,10A4,2I5,
     1I10,I5)
      READ(5,403)FMT2
  403 FORMAT( 20A4)
      WRITE(6,FMT2)TC1,TC2,TC3,TC4
C       SKIP DIRECTLY TO PRINTING DATA, IF THERE IS NONE TO BE SKIPPED.
      K=0
      NREC=0
   77 IF(ND.EQ.0)GO TO 99
C
C       READ THE UNWANTED DATA
      K=1
    8 READ(4,9,END=200,ERR=190)
    9 FORMAT(79X,I1)
      IF(K.GE.ND) GO TO 99
      K=K+1
      GO TO 8
C       END OF UNWANTED DATA LOOP
C
   99 NREC=K
C
      NOPAGE=NOPAGE+1
```

```
      WRITE(6,50)
   50 FORMAT('1')
      WRITE(6,3) NOPAGE
    3 FORMAT(9X,'NODC DATA FOR ATLANTIC,SE COAST,INSHORE,CHARLESTON AREA
     1S, PAGE , ',I3//)
      NPG=NPG+3
      K=0
C
C      ----------BEGIN MAIN LOOP----------
C
   11 CONTINUE
C
C      HDR1 AND HDR2 CONTAIN ALL HEADER INFO EXCEPT TYPE WHICH IS THE
C      TEST VARIABLE TYP
C
      NREC=NREC+1
C
C      THE NEXT CARD IS ONLYNTO BE USED FOR NPS688 IN THE ATLANTIC
C
      IF(NREC.GE.90865)GO TO 194
      READ(4,110,END=200,ERR=190)HDR1,HDR2,TYP
  110 FORMAT(19A4,A3,I1)
      IF(TYP.NE.1)GO TO 11
      NN=NN+1
      READ(99,FMT1)IA,IB
      CALL TEST(IANS,MD1,MD2,MD3,TC1,TC2,TC3,TC4,IA,IB)
C     A RETURN OF IANS=1 INDICATES TEST SATISFIED
      IF(IANS.NE.1)GO TO 11
      READ(99,10)                   CC,SH,LATD,LATM,LOND,LONM,MSQ,YR,
     1MO,DAY,HR,CRNO,STANO,DPTH,SDTH,NOBS,STA2,ID1,ID2,TYP
   10 FORMAT(3A2,4A3,3A2,3A3,A4,2A2,26X,A2,2X,2A4,I1)
   12 N=N+1
C        WRITE THE HEADING FOR THE HEADER RECORD DATA.
    5 WRITE(6,4)
    4 FORMAT(5X,'CTY SHP LAT(N)  LONGITUD MSQ  YR MO DY HR   CRNO STANO D
     1PTH SDTH NOBS     ID     TYP    N        NN       NREC    '/)
C      CC=COUNTRY,SH=SHIP,LAT IS LATITUDE,LON IS LONGITUDE,MSQ IS
C      MARSDEN SQUARE, YR=YEAR, MO=MONTH, HR=HOUR,GCT, STANO=SHIPS
C      STATION NO , DPTH IS DEPTH TO BOTTOM,SDTH=DEPTH OF STATION,
C      ID IS NODC IDENTIFICATION,TYP IS CARD TYPE.
C
      NPG=NPG+2
      WRITE(6,20) CC,SH,LATD,LATM,LOND,LONM,MSQ,YR,MO,DAY,HR,CRNO,
     1STANO,STA2,DPTH,SDTH,NOBS,ID1,ID2,TYP,N,NN,NREC
   20 FORMAT(5X,A2,2X,A2,2X,A2,'-',A3,2X,A3,'-',A3,2X,A3,3(1X,A2),
     11X,A3,2X,A3,2X,A3,A2,1X,A4,2X,A2,3X,A2,2X,2A4,2X,I1,3I7)
      WRITE(6,24)
   24 FORMAT(' ')
```

```
      NPG=NPG+2
C      WRITE HEADING FOR DATA
      WRITE(6,25)
   25 FORMAT(T8,'DEPTH',T15,'TEMPERATURE',T28,'SALINITY',T38,'SIGMA-T',
     1T48,'OXYGEN',T59,'SV',T64,'TYPE'/)
      NPG=NPG+2
C
   27 NREC=NREC+1
C      READ DATA
      READ(4,30,END=200,ERR=192) D,T1,T2,T21,    T22,S1,S2,ST1,ST2,
     1SV2,SV3,O1,O2,TYP
   30 FORMAT(T28,A4,1X,A2,3A1,A2,A3,A2,A2,T47,A3,A1,A1,A2,T80,I1)
      IF(TYP.NE.1)GO TO 31
      NN=NN+1
C      PRINT ABOUT 75 LINES ON A PAGE
      IF(NPG.LE.50)GO TO 32
      NOPAGE=NOPAGE+1
      NPG=0
      WRITE(6,50)
      WRITE(6,3)NOPAGE
   32 READ(99,FMT1)IA,IB
      CALL TEST(IANS,MD1,MD2,MD3,TC1,TC2,TC3,TC4,IA,IB)
      IF(IANS.NE.1)GO TO 11
      READ(99,10)CC,SH,LATD,LATM,LOND,LONM,MSQ,YR,MO,DAY,HR,CRNO,STANO,
     1DPTH,SDTH,NOBS,STA2,ID1,ID2,TYP
      GO TO 12
C      WE EXAMINE T21, WHICH HAS AN OVERPUNCH FOR A MINUS SIGN,
C      BECOMING D1,D2,ETC. AND DO INSTEAD OF F1,F2, AND FO.
C      WE START BY SUBTRACTING ZFO.  IF THE RESULT IS .GT. ZERO, THE
C      DIGIT HAD NO OVERPUNCH AND WE RECREATE THE DIGIT.  IF THE
C      RESULT IS .LT. ZERO, WE SUPPLY THE MINUS SIGN, FIND OUT IF IT WAS
C      A DIGIT .GT. ZERO BY A SIMILAR PROCEDURE, ETC.
   31 NB=T21-F1
      IF(NB.GE.0) GO TO 33
C      SIGN MUST BE NEGATIVE.
      SGN=SGN2
C      RECREATE ORIGINAL DIGIT AND SUBTRACT ZDO: THIS ALSO CONVERTS
C      A Z50 INTO A 10000000, A -0.
      NB=NB+F1-D1
      IF(NB.GE.0) GO TO 35
C      RECREATE DIGIT IF IT WAS NOT AMONG 0 TO 9 AND PRINT IT UNCHANGED.
      NB=NB+D1
      GO TO 37
   33 SGN=SGN1
   35 NB=NB+F1
   37 WRITE(6,95) D,SGN,T1,DOT,T2,NB,T22,S1,DOT,S2,ST1,DOT,ST2,O1,DOT,
     1O2,SV1,SV2,DOT,SV3,TYP
   95 FORMAT(T9,A4,T18,A1,A2,4A1,T30,A2,A1,A3,T39,A2,A1,A2,T49,A1,A1,
```

```
     1A2,T57,A1,A3,A1,A1,T66,I1)
  90 NPG=NPG+1
     GO TO 27
C     --------END OF DATA-READ LOOP
C
C     ----------END OF MAIN LOOP
C
 190 IF(K.EQ.0) GO TO 192
     WRITE(6,191) K,CC,SH,LATD,LATM,LOND,LONM,ID1,ID2,TYP
 191 FORMAT(//5X,'READ ERROR IN SKIP LOOP; CONTINUE.  K= ',I6/)
     K=K+1
     GO TO 8
 192 WRITE(6,193)NREC
 193 FORMAT(//5X,'READ ERROR IN DATA-READ LOOP; CONTINUE.  NREC= ',I6/)
     NREC=NREC+1
     GO TO 27
 194 WRITE(6,195)
 195 FORMAT(//5X,' END OF ATLANTIC OCEAN DATA ')
     GO TO 999
 200 WRITE(6,205)
 205 FORMAT(//5X,'END OF FILE')
     GO TO 999
 999 STOP
     END
C
C     SUBROUTINE TEST
C     DOES THE TESTING FOR NODCRD MOD. 3
C
     SUBROUTINE TEST(IANS,MD1,MD2,MD3,TC1,TC2,TC3,TC4,IA,IB)
C
C     TEST THE FIRST FIELD
C
     INTEGER TC1,TC2,TC3,TC4
     IF(MD1-1) 20,40,60
  20 IF(IA.EQ.TC1)GO TO 30
     IANS=0
     GO TO 999
  30 IANS=1
     IF(MD3.EQ.0)GO TO 999
     GO TO 100
C
  40 IF(IA.GE.TC1)GO TO 50
     IANS=0
     GO TO 999
C
  50 IANS=1
     IF(MD3.EQ.0)GO TO 999
     GO TO 100
```

```
   60 IF(IA.GE.TC1)GO TO 65
      IANS=0
      GO TO 999
   65 IF(IA.LE.TC2)GO TO 70
      IANS=0
      GO TO 999
   70 IANS=1
      IF(MD3.EQ.0)GO TO 999
C
C       MD3.NE.0; TEST A SECOND FIELD
C
  100 IF(MD2-1)120,140,160
  120 IF(IB.EQ.TC3)GO TO 999
      IANS=0
      GO TO 999
  140 IF(IB.GE.TC3)GO TO 999
      IANS=0
      GO TO 999
C
  160 IF(IB.GE.TC3)GO TO 165
      IANS=0
      GO TO 999
  165 IF(IB.LE.TC4)GO TO 999
      IANS=0
      GO TO 999
C
  999 RETURN
      END
//GO.FT04F001 DD UNIT=3400-4,VOL=SER=NPS688,DISP=(OLD,KEEP),
//   DCB=(DEN=2,RECFM=FB,LRECL=80,BLKSIZE=3200),LABEL=(1,SL,,IN),
//   DSN=S2514.NDC2
//GO.SYSIN  DD  *
(10A4,4X,I1,4X,I1,1X,I2,2X,I2,2X,I1,1X,A4,A4,I6,5X)
(20X,I2,I2,56X)                          0     0 01                    087890
(1X,'TC1=',I2,',TC2=',I2,',TC3=',A4,',TC4=',A4)
```

```
C
C      ******************** CHTPLT, MOD 5 ********************
C
C
C       R. G.  PAQUETTE  SEPT. 19, 1978
C
C      ADAPTATION OF CHTPLT MOD 2 TO PLOT POSITION AND
C       SYMBOLS FOR NOSE (N), SHALLOW FINE STRUCTURE (S,3 WEIGHTS), DEEP
C       FINE STRUCTURE (D,3 WEIGHTS).  IN ADDITION TO STATION IDENTIFYING
C       INFORMATION AND POSITION THE DATA CARD HAS 3 ONE-BYTE VARIABLES:
C       JN, JS, JD FOR NOSE (0= NO NOSE), SHALLOW STRUCTURE (0=NONE,
C       1=WEAK,2=MEDIUM,3=STRONG), DEEP STRUCTURE CODED LIKE SHALLOW.
C       WE PLOT POSITION WITH A 0.14 CROSS, NOSE WITH A .07 N TO THE LEFT,
C       SHALLOW STRUCTURE AS S (STRONG), M (MEDIUM) AND W (WEAK) IN
C       0.07 SIZE ABOVE:  DEEP STRUCTURE SIMILARLY, TO THE RIGHT, IN .14 SIZE.
C       TO READ JD ONLY CHANGE FMT CARD FROM (...30X,3I1) TO
C       (...28X,2I1,2X,I1).  TO READ JN ONLY CHANGE TO  (...30X,I1,2X,2I1).
C       TO READ JS ONLY CHANGETO (...29X,I1,1X,I1,1X,I1).  TO READ POSITION
C      ONLY CHANGE TO (...33X,3I1).
C      WE READ SALINITY AND POSITION FROM A SINGLE CARD.
C      ALSO WE READ A VARIABLE FORMAT FMT
C       THIS MODIFIES CHTPLT MOD. 1A TO PLOT ON A MERCATOR PROJECTION
C       (OR ANY OTHER PROJECTION WITH APPROPRIATE SUBROUTINE).  ALL THE
C       PRECEEDING VARIABLES ARE USED BUT WE ADD TWO MORE TO &CONTRL:
C       XLGTH, THE LENGTH IN INCHES OF ONE DEGREE OF LONGITUDE AND SHRK,
C       A FACTOR CORRECTION TO THE LATITUDE SCALE TO ALLOW FOR UNEVEN
C       SHRINKAGE OF THE PAPER OF THE CHART.
C       PROGRAM CHTPLT TO PLOT CONIC PROJECTION CHART OF STATION
C       THIS MOD ADDS STATION STORAGE AND REDUCES TRACK STORAGE.
C       POSITIONS FOR A SMALL AREA
C       WE CONVERT LATITUDES AND LONGITUDES FOR PLOTTING, USING A APPROX-
C       IMATION TO THE LAMBERT PROJECTION, PROJECTING ON A CONE TANGENT
C       TO THE SPHERE AT MID-LATITUDE, XMDLAT.  WE CENTER THE PLOT ON
C       LONGITUDE XMDLO SUCH THAT THE RANGE OF LONGITUDE, RNGLO, CONVERTS
C       TO W INCHES OF PLOT WIDTH AT THE LOWEST LATITUDE USED, XLATO.
C       LOGICAL VARIABLES STA AND TRAK, IF TRUE, PERMIT COMPUTING AND P
C       PRINTING STATION COORDINATES AND TRACK COORDINATES.    IF PLT
C       ALSO IS TRUE, STATION POSITIONS AND CRUISE TRACK ARE PLOTTED BOTH
C       ON THE PRINTER AND ON THE PLOTTER.  STATIONS ARE PLOTTED WITH
C       ASTERISKS AND INTERCONNECTIONG LINES.  THE TRACK IS PLOTTED
C       AS A LINE WITH DOTS EVERY 12TH ENTRY.  THE COAST (PRESENTLY
C       18 POINTS) IS PLOTTED EACH TIME AS WELL AS THE INTERSECTIONS OF
C       EACH DEGREE OF LONGITUDE WITH EACH HALF-DEGREE OF LATITUDE.  THE
C       ARRAY IS GENERATED FOR A PARTICULAR AREA AND MUST BE REVISED FOR
C       OTHER AREAS.  INPUT DATA CONSISTS OF TWO NAMELISTS AND A SET OF
C       CONVENTIONAL DATA CARDS FOR EITHER THE STATIONS OR THE TRACK,
C       ALTHOUGH ONE COULD PLOT BOTH IF HE DIDN'T MIND THE MESS.
C      MODIFIED FOR VERSATEC(FORTCLGV)19 SEPT 78. NOW PERMITS NEGATIVE
```

```
C       LONGITUDES(E LONG.). PLOTS LONGITUDE ON THE PAPER WIDTH.  NOTE: N-S
C       LIMIT OF 21 INCHES AND E-W LIMIT OF 21 INCHES(CAN BE CHANGED BY JCL).
C        SCALING IS DONE CONCEPTUALLY WITH XLONGO AS THE X ZERO IN
C        MIDSCALE. XLONGO IS AUTOMATICALLY SET= XMDLO. SETTING XLFSPC
C        THE X-OFFSET AT ABOUT PAPER CENTER(10.5 INCHES- INITIALIZED)
C        PERMITS PLOTTING EITHER SIDE OF XMDLO TO A MAXIMUM OF 10.5 IN.
C        IF THE DEFAULT X LIMIT IS TO BE EXCEEDED ANOTHER LARGER CHOICE
C        OF XLFSPC SHOULD BE MADE.
C
      DIMENSION CSTLA(400),CSTLO(400),CORLA(200),CORLO(200),XMLO(240),
     1STALA(240),STALO(240),XMLA(240),TRLA(480),YMLA(480),TRLO(480),
     2YMLO(480),TRKA(40),TRKO(40),CORLA1(200),CORLO1(200),IST(15),
     3ICST(15),NPLT(15),        FMT(20),SH(240),YR(240),STA(240)
      INTEGER*2 JN(240),JS(240),JD(240)
      EQUIVALENCE (CORLA(1),CORLA1(1)),(CORLO(1),CORLO1(1))
      LOGICAL STAN,TRAK,PLT,CST,STAD,TRKD
      NAMELIST/COAST/CSTLA,NC,CSTLO/CONTRL/ISTOP,STAN,TRAK,NSTA,NTRK,
     1PLT,XLATO,XMDLAT,XMDLO,RNGLO,W,XLFSPC,DELLA,DELLO,JSTART,JFINSH,
     2STAD,TRKD,CST,XLGTH,SHRK/LIMIT/XLIM1,XLIM2,YLIM1,YLIM2
C
      ISTOP=0
      XLFSPC=10.5
      STAN=.TRUE.
      STAD=.FALSE.
      TRKD=.TRUE.
      TRAK=.FALSE.
      PLT=.FALSE.
      CST=.FALSE.
      RAD=3.14159/180.
      SHRK=1.
C
C        ZERO ARRAYS
      DO 4 J=1,400
      CSTLA(J)=0.
    4 CSTLO(J)=0.
      DO 401 J=1,200
      CORLA(J)=0.
  401 CORLO(J)=0.
C
C       INPUT & CONTROL & LIMIT & FMT & COAST
    5 READ(5,CONTRL)
      XLONGO=XMDLO
      WRITE(6,CONTRL)
      IF(ISTOP.GT.0) GO TO 999
      READ(5,LIMIT)
      WRITE(6,LIMIT)
      READ(5,402) FMT
      WRITE(6,403)FMT
```

```
  402  FORMAT(20A4)
  403  FORMAT(1X,20A4)
       IF(.NOT.CST) GO TO 6
       READ(5,COAST)
C       COUNT THE ENTRIES
       J=1
  551  IF(CSTLA(J).LT..01) GO TO 553
       J=J+1
       GO TO 551
  553  J=J-1
       NCLA=J
       WRITE(6,556) NCLA
  556  FORMAT(/5X,'NCLA= ',I4)
       WRITE(6,557)
  557  FORMAT(//25X,'LAT AND LONG OF COAST COORDINATES'/)
C       WRITE COAST ARRAYS.
       WRITE(6,57)(CSTLA(J),CSTLO(J),J=1,NCLA)
   57  FORMAT(7(1X,F7.3,F8.3))
C
C***************************************READ STATION DATA***************
C
    6  IF(.NOT.STAN) GO TO 30
       WRITE(6,53)
   53  FORMAT(' ')
C      INPUT OF STATION COORDINATES REQUIRES UP TO 240 CARDS, ONE SET OF
C       COORDINATES TO A CARD, NORMALLY IN DEGREES, MINUTES AND TENTHS,
C       BUT MAY BE IN DEGREES AND DECIMALS IF STAD=T.
C      FORMAT IS VARIABLE. WE ALSO READ SALINITY.STOP READING ON BLANK
C      CARD. ************
       J=1
   11  READ(5,FMT)STALA(J),XMLA(J),STALO(J),XMLO(J),YR(J),STA(J),
      1JN(J),JD(J),JS(J)
       IF(STALA(J).EQ.0.)GO TO 110
       J=J+1
       GO TO 11
  110  J=J-1
       NCARDS=J
       NSTA=J
       WRITE(6,112) J,YR(J),STA(J),STALA(J),XMLA(J),STALO(J),XMLO(J),
      1JN(J),JS(J),JD(J)
  112  FORMAT(/3X,'LAST VALUE OF J,YR,STA,STALA,XMLA,STALO,XMLO,JN,JS,
      1JD:'/3X,I3,1X,A2,1X,A4,4F5.1,1X,3(1X,I1)/)
       XMIN1=60.
       IF(STAD) XMIN1=100.
       DO 20 J=1,NSTA
       STALA(J)=STALA(J)+XMLA(J)/XMIN1
       IF(STALO(J).GE.0)GO TO 19
       STALO(J)=STALO(J)-XMLO(J)/XMIN1
```

```
      GO TO 20
   19 STALO(J)=STALO(J)+XMLO(J)/XMIN1
   20 CONTINUE
  201 WRITE(6,53)
      WRITE(6,21)
   21 FORMAT('      J  STA YR  STALA   STALO  JN JS JD'/)
      DO 210 J=1,NCARDS
  210 WRITE(6,22) J,STA(J),YR(J),STALA(J),STALO(J),JN(J),JS(J),JD(J)
   22 FORMAT(3X,I5,1X,A4,1X,A2,2F9.3,3(2X,I1))
C  22 FORMAT( 2(3X,I3,2X,A2,A4,2X,2F8.3,1X,F5.1))    FOR INTGST
C
C    ***********************************END STATION INPUT**************
C
C       READ TRACK COORDINATES IN SAME FORM AS STATION COORDS. AND
C       CONVERT TO DECIMAL.
   30 IF(.NOT.TRAK) GO TO 50
      READ(5,10)(TRLA(J),YMLA(J),TRLO(J),YMLO(J),J=1,NTRK)
   10 FORMAT( 6(F3.0,F3.1,F3.0,F3.1))
      WRITE(6,53)
      WRITE(6,12)(TRLA(J),YMLA(J),TRLO(J),YMLO(J),J=1,NTRK)
   12 FORMAT( 3( 5X,F4.0,'-',F4.1,5X,F4.0,'-',F4.1))
      XMIN2=60.
      IF(TRKD)  XMIN2=100.
      DO 40 J=1,NTRK
      TRLA(J)=TRLA(J)+YMLA(J)/XMIN2
   40 TRLO(J)=TRLO(J)+YMLO(J)/XMIN2
      WRITE(6,53)
   42 CONTINUE
C
C************************************CREATE COORDINATE FIELD********
C
C       CREATE COORDINATE FIELD
   50 XLAO=XLATO-DELLA
      XLOB=XMDLO-RNGLO/2.-DELLO
C       FIND LOOP PARAMETERS
      XJLAT=(XMDLAT-XLATO)/DELLA*2.+.01
      JLAT=IFIX(XJLAT)+1
C       TEST TO SEE THAT THE RANGE IN LATITUDE IS AN INTEGRAL
C       NUMBER OF DELLA UNITS, AND SIMILARLY FOR LONGITUDE.
      XJLAT1=JLAT
      IF((XJLAT-XJLAT1).GT.1.05) WRITE(6,51) XJLAT
   51 FORMAT(5X,'WARNING*******.  COUNT OF COORDINATES IS IMPROPER--XLAT
     1,JLAT=  ',F5.2,I5)
      XJLO=RNGLO/DELLO+1.01
      JLO=IFIX(XJLO)
      XJLO1=FLOAT(JLO)
      IF((XJLO-XJLO1).GT..05) WRITE(6,510) XJLO,JLO
  510 FORMAT( 5X,'WARNING******COUNT OF LONGITUDE LEVELS NOT CONSISTENT
```

```
     1WITH DELLO.  XJLO,JLO= ',F5.2,I5)
C
C       TEST TO SEE IF JLAT*JLO IN RANGE
      NCOORD=JLAT*JLO
      IF(NCOORD.LE.200) GO TO 512
      WRITE(6,511) NCOORD
  511 FORMAT(/1X,'XXXXXX STORAGE EXCEEDED FOR COORDINATES; NCOORD= ',I5)
      GO TO 999
  512 WRITE(6,513)
  513 FORMAT(//30X,'COORDINATE FIELD, LAT AND LONG'/)
      DO 52 J=1,JLAT
      XLAO=XLAO+DELLA
      DO 52 K=1,JLO
      XK=FLOAT(K)*DELLO
      L=(J-1)*JLO+K
      CORLA(L)=XLAO
      CORLO(L)=XLCB+XK
   52 CONTINUE
C       SCAN LONGITUDES FOR .GT. 180 AND TRANSFORM TO NEGATIVE LONGS.
      DO 540 J=1,NCOORD
      IF(CORLO(J).GT.180.)CORLO(J)=CORLC(J)-360.
  540 CONTINUE
      WRITE(6,55)(CORLA(J),CORLO(J),J=1,L)
   55 FORMAT( 5(3X,F5.2,1X,F7.2))
      WRITE(6,53)
      WRITE(6,56) NCOORD
   56 FORMAT(5X,'NCOORD= ',I5)
      WRITE(6,53)
C
C************************************END COORDINATE FIELD CREATION**
C
C       PLOT
      IF(.NOT.PLT) GO TO 90
      CALL PLCTS
      CALL PLOT(0.,2.,-3)
   90 CONTINUE
C
C       COMPUTE CONSTANTS
      PI2=3.14159/2.
C
C************************************SCALE AND PLOT COORDINATE FIELD
C
      CALL SCLCHT(CORLA1,CORLO1,NCOORC,XLGTH,XLFSPC,SHRK,XLATO,XLONGO)
      WRITE(6,53)
      WRITE(6,1015)
 1015 FORMAT(//15X,'SCALED CROSS COORDINATES,Y, X'//)
      WRITE(6,1020)(CORLA1(J),CORLO1(J),J=1,NCOORD)
 1020 FORMAT(4(2X,E11.4,1X,E11.4))
```

```
C        TEST FOR OUT OF RANGE VALUES
       DO 1021 J=1,NCOORD
       IF(CORLA1(J).LT.YLIM1) CORLA1(J)=YLIM1
       IF(CORLA1(J).GT.YLIM2) CORLA1(J)=YLIM2
       IF(CORLO1(J).GT.XLIM2) CORLO1(J)=XLIM2
  1021 IF(CORLO1(J).LT.XLIM1) CORLO1(J)=XLIM1
       IF(.NOT.PLT) GO TO 1030
       MCOORD=-NCOORD
       CALL LINE(CORLO1,CORLA1,NCOORD,1,-5)
       IPLACE=1021
       WRITE(6,2000) IPLACE
  2000 FORMAT( 5X,'IPLACE= ',I5/)
       CALL PLOTP(CORLO1,CORLA1,MCOORD,1)
C
C************************************END COORDINATE FIELD***********
C
C        COMPUTE COAST COORDINATES AND PLCT
  1030 IF(.NOT.CST) GO TO 1060
C        EXAMINE THE COAST COORDINATES AND FIND THE INDEXES OF THE SEGMENTS
C        SEPARATED BY LAT=99.  THE ARRAY MUST END WITH LAT=99 AND THE
C        FOLLOWING LATITUDE=00.      WE ALSO CONSTRUCT THE ARRAY SO THAT
C        THERE ARE POINTS ON THE EVEN DEGREES AND HALF DEGREES OF LATI-
C        TUDE, OR LONGITUDE IF THE COAST IS MAINLY E-W.  THIS MAKES IT
C        CONVENIENT TO SET UP FOR DIFFERENT LATITUDE AND LONGITUDE RANGES.
C        WE CAN USE ONLY PART OF THE ARRAY BY SPECIFYING JSTART AND JFINSH
       J=JSTART
       K=1
  1032 IF(CSTLA(J).GT.91) GO TO 1034
       IF(J.GE.JFINSH) GO TO 1035
       J=J+1
       GO TO 1032
  1034 ICST(K)=J
C        RESET THE DELIMITERS TO VALUES WHICH DO NOT BLOW UP IN ALOG.
       CSTLA(J)=89.
       CSTLO(J)=1.
       CSLAJ1=CSTLA(J+1)
C        IF THE NEXT ONE IS BLANK, IT IS THE END OF THE ARRAY.
       IF(CSLAJ1.LT..1) GO TO 1035
       J=J+1
       K=K+1
       IF(K.GT.15) GO TO 1038
       GO TO 1032
  1035 NSEG=K
C        IF THERE ARE FEWER VALUES THAN EXPECTED, CHANGE JFINSH.
       ICST(K)=J
       NSEG=K
       JFINSH=J
  1037 WRITE(6,1036) NSEG,(ICST(K),K=1,NSEG)
```

```
 1036 FORMAT(/5X,'COAST ARRAY CONSISTS OF ',I2,' SEGMENTS ENDING ON NUMB
     1ERS ',10I4/)
      GO TO 1040
 1038 WRITE(6,1039)
 1039 FORMAT(5X,'EXCEEDED THE LIMIT OF THE ICST ARRAY')
      NSEG=K-1
      JFINSH=J-1
      GO TO 1037
 1040 CONTINUE
      NCT=JFINSH-JSTART+1
      CALL SCLCHT(CSTLA(JSTART),CSTLO(JSTART),NCT,XLGTH,XLFSPC,SHRK,
     1XLATO,XLONGO)
C       TEST FOR OUT OF RANGE VALUES
      DO 1041 J=JSTART,JFINSH
      IF(CSTLA(J).LT.YLIM1) CSTLA(J)=YLIM1
      IF(CSTLA(J).GT.YLIM2) CSTLA(J)=YLIM2
      IF(CSTLO(J).GT.XLIM2) CSTLO(J)=XLIM2
 1041 IF(CSTLO(J).LT.XLIM1) CSTLO(J)=XLIM1
      WRITE(6,1043)
 1043 FORMAT(//15X,'SCALED COAST COORDINATES,Y, X'//)
      WRITE(6,1020)( CSTLA(J),CSTLO(J),J=JSTART,JFINSH)
 1042 FORMAT(6(2X,E11.4))
      WRITE(6,53)
      IF(.NOT.PLT) GO TO 1060
C
C       THE NEXT ROUTINE PLOTS THE COAST IN SEGMENTS
C       COMPUTE THE NUMBER OF POINTS TO BE PLOTTED BEFORE THE PEN IS
C       LIFTED (NPLT) AND THE START OF EACH SEQUENCE (IST)
      NPLT(1)=ICST(1)-JSTART
      IST(1)=JSTART
      DO 1046 J=2,NSEG
      NPLT(J)=ICST(J)-ICST(J-1)-1
 1046 IST(J)=ICST(J-1)+1
      M=2
      IF(.NOT.STAN.AND..NOT.TRAK) M=3
      DO 1047 J=1,NSEG
      IA=IST(J)
      NC=NPLT(J)
      IB=-NC
      IPLACE=1046
      WRITE(6,2000) IPLACE
      CALL PLOTP(CSTLO(IA),CSTLA(IA),IB,M)
 1047 CALL LINE(CSTLO(IA),CSTLA(IA),NC,1,1)
      IF(.NOT.STAN) GO TO 107
C
C*****************************************SCALE AND PLOT STATIONS********
C
 1060 CONTINUE
```

```
      CALL SCLCHT(STALA,STALO,NSTA,     XLGTH,XLFSPC,SHRK,XLATO,XLONGO)
      WRITE(6,1062)
 1062 FORMAT(//15X,'SCALED STATION COORDINATES, Y, X'//)
      WRITE(6,1020)(STALA(J),STALO(J),J=1,NSTA)
C     THROW THE POINTS OUT OF LIMITS. COUNT TOTAL POINTS WITH J,
C     GOOD POINTS WITH K
      J=0
      K=1
 1064 J=J+1
      IF(J.GT.NSTA) GO TO 1065
      IF(STALO(J).LT.XLIM1) GO TO 1064
      IF(STALO(J).GT.XLIM2) GO TO 1064
      IF(STALA(J).GT.YLIM2) GO TO 1064
      IF(STALA(J).LT.YLIM1) GO TO 1064
      STALA(K)=STALA(J)
      STALO(K)=STALO(J)
      JN(K)=JN(J)
      JS(K)=JS(J)
      JD(K)=JD(J)
      K=K+1
      GO TO 1064
 1065 NCARDS=K-1
      NSTA=NCARDS
C
      KD=J-K
      WRITE(6,1066) KD
 1066 FORMAT(3X,'DISCARDED ',I3,' STATIONS')
      IF(.NOT.PLT) GO TO 107
      DO 1063 J=1,NCARDS
C       PLOT POSITION
      XP=STALO(J)-0.045
      YP=STALA(J)-0.08
      XF1=XP+.07
      CALL SYMBOL(XP,YP,.14,'+',0.,1)
C       PLOT NOSE SYMBOL
      IF(JN(J).EQ.0) GO TO 1067
      XP=STALO(J)-0.14
      YP=STALA(J)-.035
      CALL SYMBOL(XP,YP,.07,'N',0.,1)
C       PLOT SHALLOW SYMBOL
 1067 IF(JS(J).EQ.0) GO TO 1071
      XP=STALO(J)-0.035
      YP=STALA(J)+0.09
      IF(JS(J).GT.1) GO TO 1069
      CALL SYMBOL(XP,YP,.07,'A',0.,1)
      GO TO 1071
 1069 IF(JS(J).GT.2) GO TO 1070
      CALL SYMBOL(XP,YP,.07,'B',0.,1)
```

```
      GC TO 1071
 1070 CALL SYMBOL(XP,YP,.07,'C',0.,1)
C       PLOT DEEP SYMBOL
 1071 IF(JD(J).EQ.0) GO TO 1063
      XP=STALO(J)+0.08
      YP=STALA(J)-0.07
      IF(JD(J).GT.1) GO TO 1073
      CALL SYMBOL(XP,YP,.14,'A',0.,1)
      GO TO 1063
 1073 IF(JD(J).GT.2) GO TO 1074
      CALL SYMBOL(XP,YP,.14,'B',0.,1)
      GO TO 1063
 1074 CALL SYMBOL(XP,YP,.14,'C',0.,1)
 1063 CONTINUE
      IF(.NOT.TRAK) M=3
      IB=-NSTA
      IPLACE=1061
      WRITE(6,2000) IPLACE
      CALL PLOTP(STALO, STALA,IB,M)
  107 IF(.NOT.TRAK) GO TO 120
C
C*************************************END STATIONS******************
C
 1080 CONTINUE
      CALL SCLCHT(TRLA,TRLO,NTRK,       XLGTH,XLFSPC,SHRK,XLATO,XLONGO)
      WRITE(6,53)
C       TEST FOR OUT OF RANGE VALUES
      DO 1081 J=1,NTRK
      IF(TRLA(J).LT.XLIM1) TRLA(J)=XLIM1
      IF(TRLA(J).GT.YLIM2) TRLA(J)=YLIM2
      IF(TRLO(J) .LT.XLIM1) TRLO(J)=XLIM1
 1081 IF(TRLO(J).GT.XLIM2) TRLO(J)=XLIM2
      WRITE(6,1082)
 1082 FORMAT(//'SCALED TRACK COORDINATES, Y, X'//)
      WRITE(6,1020)(TRLA(J),TRLO(J),J=1,NTRK)
      IF(.NOT.PLT) GO TO 1100
      CALL LINE(TRLO,TRLA,NTRK,1,1)
C
C       PUT MARKS IN EVERY 12 POINTS
      NTRK1=NTRK/12
 1100 DO 1101 J=1,NTRK1
      KK=12*(J-1)+1
      TRKA(J)=TRLA(KK)
 1101 TRKO(J)=TRLO(KK)
      WRITE(6,53)
      WRITE(6,1042)(TRKA(J),J=1,NTRK1)
      WRITE(6,53)
      WRITE(6,1042)(TRKO(J),J=1,NTRK1)
```

```
      IF(.NOT.PLT) GO TO 998
      CALL LINE(TRKO,TRKA,NTRK1,1,-3)
      IB=-NTRK1
      CALL PLOTP(TRKO,TRKA,IB,3)
C
C      PUT IN A LABEL
  120 YLB=YLIM2+1.
      CALL SYMBOL(0.,YLB,.28,'R.H.BOURKE-BOX 110',0.,19)
C
C      RESET PEN
      YLB=YLIM2+4.
      CALL PLOT(0.,YLB,-3)
C
C      TERMINATE PLOT
      CALL PLOTE
      WRITE(6,990)
  990 FORMAT(/3X,'PLOT SHOULD BE COMPLETED')
  998 GO TO 5
  999 STOP
      END
C      --------------- SUBROUTINE SCLCHT ----------------
C      THIS SUBROUTINE IS FOR USE WITH CHTPLT, MOD. 2.  IT ACCEPTS
C      COORDINATE PAIRS IN THE ORDER LATITUDE, LONGITUDE, IN DEGREES AND
C      DECIMAL FRACTIONS OF A DEGREE AND RETURNS TO THE SAME ARRAYS
C      PLOTTING COORDINATES IN INCHES FOR A MERCATOR PROJECTION.  Y IS
C      THE LATITUDE ARRAY, X THE LONGITUDE ARRAY,N IS THE NUMBER OF
C      POINTS IN THE ARRAY, XLGTH IS THE LENGTH OF ONE DEGREE OF LONGI-
C      TUDE IN INCHES AND SHRK IS A CORRECTION FACTOR TO CORRECT FOR
C      UNEVEN PAPER STRETCH OR SHRINKAGE, APPLIED TO THE LATITUDE SCALE.
C      THE LOWEST LATITUDE IS XLATO AND THE HIGHEST WEST LONGITUDE IS
C      XLONGO, BOTH IN DEGREES.
C
      SUBROUTINE SCLCHT(Y,X,N,XLGTH,XLFSPC,SHRK,XLATO,XLONGO)
      DIMENSION Y(1),X(1)
C
      PI=3.141592
      PI4=PI/4.
      RAD=PI/180.
      RAD2=RAD/2.
      R=XLGTH/RAD
C      R IS THE RADIUS OF THE CYLINDER OF THE PROJECTION.
      XL=XLATO*RAD2
      RR=R*SHRK
      YLATC=ALOG(TAN(XL+PI4))*RR
C
C      YLATO IS THE DISTANCE IN INCHES FROM THE EQUATOR TO THE BASEE
C      LATITUDE.
C      TRANSFORM THE ARRAYS
```

```
      DO 10 J=1,N
      Y(J)=ALOG(TAN(Y(J)*RAD2+PI4))*RR-YLATO
      IF(X(J).GE.0.)GO TO 9
      X(J)=(XLONGO-X(J)-360.)*XLGTH+XLFSPC
      GO TO 10
    9 X(J)=(XLONGO-X(J))*XLGTH+XLFSPC
   10 CONTINUE
      RETURN
      END
//GO.SYSIN  DD  *
 &CONTRL PLT=T,XLATO=32.,XMDLO=79.0,RNGLO=4.,XLFSPC=10.5,DELLA=0.25,
 DELLO=0.25,XLGTH=3.9000,SHRK=1.0,XMDLAT=33.0,&END
 &LIMIT XLIM1=0.,XLIM2=21.,YLIM1=0.,YLIM2=21.,&END
(13X,F2.0,F3.1,4X,F4.0,F3.1,3X,A2,8X,A4,1X,3I1)
```

```
C
C
C                    *****NODPUNA*******
C
C
C        SOURCE:   ALAN J. PICKRELL/DAVID W. YEAGER
C                  SEPTEMBER 1978
C    THIS PROGRAM IS DESIGNED TO READ A STANDARD NODC MAGNETIC TAPE
C    AND PUNCH DATA CARDS CONTAINING THE FOLLOWING INFORMATION:
C    LATITUDE OF OCEANOGRAPHIC STATION,LONGITUDE OF SRATION,MONTH
C    OF OBSERVATION,NODC IDENTIFICATION CODE, AND LAST 4 DIGITS OF
C    SOUND SPEED VALUE AT EACH STANDARD DEPTH FROM 0 TO 400 METERS.
C    SOUND SPEED VALUE PUNCHED IS TO TENTHS OF A METER PER SECOND.
C    THE LEADING DIGIT (A 1 ) IN THE THOUSANDS PLACE IS NOT
C    PUNCHED. THE PROGRAM VELDAT ASSUMES THAT EACH VALUE READ FROM
C    THESE PUNCHED CARDS MUST HAVE 1000 METERS PER SECOND ADDED TO
C    THE VALUES PUNCHED ON THESE CARDS.
C
C
C    EACH CARD CONTAINS ALL THE ABOVE INFORMATION FOR EACH OCEO
C    STATION OBSERVED .
C
C    PUNCH CARD FORMAT FOLLOWS: (3A4,I3,1X,A4,12(1X,A4))
C
C    THESE PUNCH CARDS ARE DESIGNED AS INPUT TO VELDAT FOR
C    ANALYSIS OF SOUND SPEED VARIATION.
C
C    TO USE NODPUNA: AFTER FIRST  OBTAINING STATION HEADER DUMP
C    WITH PROGRAM NODCDUM,RECORD NO. OF FIRST STATION OF INTEREST
C    IS IFIRST, RECORD NO. OF LAST STATION OF INTEREST IS LASTRC.
C    STATIONS OBSERVED DURING A PARTICULAR MONTH ARE OBTAINED BY
C    SPECIFYING MONTH.
C    THESE SPECIFICATIONS ARE MADE BY PROVIDING THREE INPUT CARDS:
C    IFIRST=XXXXXXX
C    LASTRC=XXXXXXX
C    MONTH=XX
C
C    AFTER THESE INPUT VARIABLES HAVE BEEN SPECIFIED, PROGRAM
C    WILL READ THE ENTIRE MAGNETIC TAPE, DATA CARDS FOR ALL STATIONS
C    BETWEEN IFIRST AND LASTRC WHICH WERE OBSERVED DURING THE
C    MONTH CORRESPONDING TO THE MONTH SPECIFIED WILL BE PUNCHED.
C
C
   DIMENSION LALDIN(3),LALOUT(3),VELTAB(12),STDDEP(12)
   LOGICAL USING
   DATA BLANK/'    0'/,STDDEP/ '0000','0010','0020','0030',
  *'0050','0075','0100','0150','0200','0250','0300','0400'/
   CALL REREAD
```

```
      MONTH = 12
      IFIRST=85700
      LASTRC=87890
      REWIND 4
      NREC = 1
20    READ (4,800,END=900,ERR=900)
800   FORMAT(79X,I1)
      IF (NREC .GE. IFIRST) GO TO 90
      NREC=NREC+1
      GO TO 20
C
C
90    USING = .FALSE.
100   READ (4,810,END=900,ERR=900) LALOIN,MNTHIN,DEPTH,VEL,IDIN,ICODE
810   FORMAT(4X,2A4,A3,5X,I2,5X,A4,15X,A4,25X,A4,I1)
      NREC=NREC+1
      IF (NREC .GT. LASTRC) GO TO 500
      IF (ICODE .NE.1) GO TO 300
      IF (USING) WRITE (7,820) LALOUT,MONTH,IDOUT,VELTAB
820   FORMAT (3A4,I3,1X,A4,12(1X,A4))
C
      DO 120 I=1,12
120     VELTAB(I) = BLANK
      USING = .FALSE.
      IF (MNTHIN .NE. MONTH) GO TO 100
      USING = .TRUE.
      LALOUT(1)= LALOIN(1)
      LALOUT(2) = LALOIN(2)
      LALOUT(3) = LALOIN(3)
      IDOUT = IDIN
      GO TO 100
C
C
C
C
C
300   IF(.NOT. USING) GO TO 100
      IF (ICODE .NE. 3 .AND. ICODE .NE. 4 .AND. ICODE .NE. 6) GO TO 100
      DO 320 I=1,12
        IF(DEPTH .EQ. STDDEP(I)) GO TO 340
320   CONTINUE
      GO TO 100
340   VELTAB(I) = VEL
      GO TO 100
C
C
C
500   WRITE (6,830)
```

```
830    FORMAT (' END OF  DATA')
       STOP
900    WRITE (6,840)
840    FORMAT (' READ PROBLEM')
       STOP
       END
//GO.FT04F001 DD UNIT=3400-4,VOL=SER=NPS688,DISP=(OLD,KEEP),
//   DCB=(DEN=2,RECFM=FB,LRECL=80,BLKSIZE=3200),LABEL=(1,SL,,IN),
//   DSN=S2514.NDC2
//GO.SYSIN  DD  *
```

```
C
C
C             *************NODPUNB**************
C
C
C             SOURCE: A.J. PICKRELL/D.W. YEAGER
C                     SEPTEMBER 1978
C
C
C
C     THIS PROGRAM IS BASICALLY THE SAME PROGRAM AS NODPUNA.
C     IT IS DESIGNED TO READ A STANDARD NODC MAGNETIC TAPE OF
C     THE STATION DATA FILE TYPE AND PUNCH DATA CARDS CONTAINING
C     THE FOLLOWING INFORMATION: LATITUDE OF STATION,LONGITUDE OF
C     STATION,MONTH OF OBSERVATION, NODC IDENTIFICATION CODE, AND
C     SALINITY OBSERVED AT EACH STANDARD DEPTH FROM 0 TO 400 METERS.
C     SALINITIES ARE PUNCHED IN PARTS PER THOUSAND TO HUNDREDTHS
C     OF A PPT. NO DECIMAL POINT IS INSERTED BY THIS PROGRAM.
C     CARDS ARE DESIGNED AS INPUT TO SALDAT, DECIMAL POINT POSITION
C     IS MADE BY SALDAT.
C
C     EACH CARD CONTAINS ALL THE ABOVE INFORMATION FOR ONE OCEANOGRAPH-
C     IC STATION.
C
CC
C     PUNCH CARD FORMAT IS: (3A4,I3,1X,A4,12(1X,A4))
C
C     USE OF NODPUNB IS EXACTLY LIKE NODPUNA: STATIONS ARE ABSTRACTED
C     BY MONTH OF OBSERVATION . THREE INPUT CARDS MUST BE SPECIFIED:
C     IFIRST=XXXXXXX
C     LASTRC=XXXXXXX
C     MONTH= XX
C
C     IFIRST IS FIRST RECORD NUMBER OF INTEREST ON MAGNETIC TAPE
C     (THIS VALUE OBTAINED AFTER EXAMINING OUTPUT OF NODCDUM)
C     AND LASTRC IS RECORD NUMBER OF LAST STATION OF INTEREST.
C     MONTH (AS BEFORE) IS MONTH OF OBSERVATION DESIRED.
C
C     AFTER THESE INPUT VARIABLES HAVE BEEN SPECIFIED,THE PROGRAM
C     WILL IGNORE ALL RECORDS PRIOR TO IFIRST. IT WILL THEN READ
C     AND PUNCH DATA CARDS FOR ALL STATIONS OBSERVED DURING THE MONTH
C     SPECIFIED BETWEEN IFIRST AND LASTRC.
C
C
C
      DIMENSION LALOIN(3),LALOUT(3),SALTAB(12),STDDEP(12)
      LOGICAL USING
      DATA BLANK/'    0'/,STDDEP/ '0000','0010','0020','0030',
```

```
     *'C050','0075','0100','0150','0200','0250','0300','0400'/
      CALL REREAD                                                       NOD00050
      IFIRST = 85700                                                    NOD00070
      LASTRC =  90865                                                   NOD00080
      REWIND 4                                                          NOD00090
      NREC = 1                                                          NOD00100
20    READ (4,800,END=900,ERR=900)                                      NOD00110
800   FORMAT(79X,I1)                                                    NOD00120
      IF (NREC .GE. IFIRST) GO TO 90                                    NOD00130
      NREC=NREC+1                                                       NOD00140
      GO TO 20                                                          NOD00150
C                                                                       NOD00160
C                                                                       NOD00170
90    USING = .FALSE.                                                   NOD00180
100   READ (4,810,END=900,ERR=900) LALOIN,MNTHIN,DEPTH,SAL,IDIN,ICODE   NOD00190
810   FORMAT(4X,2A4,A3,5X,I2,5X,A4,6X,A4,34X,A4,I1)                     NOD00200
      NREC=NREC+1                                                       NOD00210
      IF (NREC .GT. LASTRC) GO TO 500                                   NOD00220
      IF (ICODE .NE.1) GO TO 300                                        NOD00230
      IF (USING) WRITE (7,820) LALOUT,MONTH,IDOUT,SALTAB                NOD00240
820   FORMAT (3A4,I3,1X,A4,12(1X,A4))                                   NOD00250
C                                                                       NOD00260
      DO 120 I=1,12                                                     NOD00270
120     SALTAB(I) = BLANK                                               NOD00280
      USING = .FALSE.                                                   NOD00290
      IF (MNTHIN .NE. MONTH) GO TO 100                                  NOD00300
      USING = .TRUE.                                                    NOD00310
      LALOUT(1)= LALOIN(1)                                              NOD00320
      LALOUT(2) = LALOIN(2)                                             NOD00330
      LALOUT(3) = LALOIN(3)                                             NOD00340
      IDOUT = IDIN                                                      NOD00350
      GO TO 100                                                         NOD00360
C                                                                       NOD00370
C                                                                       NOD00380
C                                                                       NOD00390
C                                                                       NOD00400
C                                                                       NOD00410
300   IF(.NOT. USING) GO TO 100                                         NOD00420
      IF (ICODE .NE. 3 .AND. ICODE .NE. 4 .AND. ICODE .NE. 6) GO TO 100 NOD00430
      DO 320 I=1,12                                                     NOD00440
        IF(DEPTH .EQ. STDDEP(I)) GO TO 340                              NOD00450
320   CONTINUE                                                          NOD00460
      GO TO 100                                                         NOD00470
340   SALTAB(I) = SAL                                                   NOD00480
      GO TO 100                                                         NOD00490
C                                                                       NOD00500
C                                                                       NOD00510
C                                                                       NOD00520
```

```
500    WRITE (6,830)
830    FORMAT (' END OF DATA')
       STOP
900    WRITE (6,840)
840    FORMAT (' READ PROBLEM')
       STOP
       END
//GO.FT04F001 DD UNIT=3400-4,VOL=SER=NPS688,DISP=(OLD,KEEP),
//   DCB=(DEN=2,RECFM=FB,LRECL=80, BLKSIZE=3200),LABEL=(1,SL,,IN),
//   DSN=S2514.NDC2
//GO.SYSIN   DD   *
```

```
C
C
C            *************NODPUNC**************
C
C
C            SOURCE:  A.J. PICKRELL/D.W. YEAGER
C                     SEPTEMBER 1978
C
C
C
C     THIS PROGRAM IS BASICALLY THE SAME PROGRAM AS NODPUNA.
C     IT IS DESIGNED TO READ A STANDARC NODC MAGNETIC TAPE OF
C     THE STATION DATA FILE TYPE AND PUNCH DATA CARDS CONTAINING
C     THE FOLLOWING INFORMATION: LATITUDE OF STATION,LONGITUDE OF
C     STATION,MONTH OF OBSERVATION, NODC IDENTIFICATION CODE, AND
C     TEMPERATURE OBSERVED AT EACH STANDARD DEPTH FROM 0 TO 400 METERS.
C     TEMPS. ARE PUNCHED IN DEG. CENTIGRADE TO HUNDREDTHS
C     OF A DEG.. NO DECIMAL POINT IS INSERTED BY THIS PROGRAM.
C     CARDS ARE CESIGNED AS INPUT TO TEMDAT, DECIMAL POINT POSITION
C     IS MADE BY TEMDAT.
C
C     EACH CARD CONTAINS ALL THE ABOVE INFORMATION FOR ONE OCEANOGRAPH-
C     IC STATION.
C
C     PUNCH CARD FORMAT IS: (3A4,I3,1X,A4,12(1X,A4))
C
C     USE OF NODPUNC IS EXACTLY LIKE NODPUNA: STATIONS ARE ABSTRACTED
C     BY MONTH OF OBSERVATION . THREE INPUT CARDS MUST BE SPECIFIED:
C     IFIRST=XXXXXXX
C     LASTRC=XXXXXXX
C     MONTH= XX
C
C     IFIRST IS FIRST RECORD NUMBER OF INTEREST ON MAGNETIC TAPE
C     (THIS VALUE OBTAINED AFTER EXAMINING OUTPUT OF NODCDUM)
C     AND LASTRC IS RECORD NUMBER OF LAST STATION OF INTEREST.
C     MONTH (AS BEFORE) IS MONTH OF OBSERVATION DESIRED.
C
C     AFTER THESE INPUT VARIABLES HAVE BEEN SPECIFIED,THE PROGRAM
C     WILL IGNORE ALL RECORDS PRIOR TO IFIRST. IT WILL THEN READ
C     AND PUNCH DATA CARDS FOR ALL STATIONS OBSERVED DURING THE MONTH
C     SPECIFIED BETWEEN IFIRST AND LASTRC.
C
C
C
      DIMENSION LALOIN(3),LALOUT(3),TEMTAB(12),STDDEP(12)
      LOGICAL USING
      DATA BLANK/'   0'/,STDDEP/ '0000','0010','0020','0030',
     *'0050','0075','0100','0150','0200','0250','0300','0400'/
```

```
      CALL REREAD                                                       NOD00050
      MONTH = 12
      IFIRST = 85700                                                    NOD00070
      LASTRC = 90865                                                    NOD00080
      REWIND 4                                                          NOD00090
      NREC = 1                                                          NOD00100
20    READ (4,800,END=900,ERR=900)                                      NOD00110
800   FORMAT( 79X,I1)                                                   NOD00120
      IF (NREC .GE. IFIRST) GO TO 90                                    NOD00130
      NREC=NREC+1                                                       NOD00140
      GO TO 20                                                          NOD00150
C                                                                       NOD00160
C                                                                       NOD00170
90    USING = .FALSE.                                                   NOD00180
100   READ (4,810,END=900,ERR=900) LALOIN,MNTHIN,DEPTH,TEM,IDIN,ICODE   NOD00190
810   FORMAT( 4X,2A4,A3,5X,I2,5X,A4,1X,A4,39X,A4,I1)                    NOD00200
      NREC=NREC+1                                                       NOD00210
      IF (NREC .GT. LASTRC) GO TO 500                                   NOD00220
      IF (ICODE .NE.1) GO TO 300                                        NOD00230
      IF (USING) WRITE (7,820) LALOUT,MONTH,IDOUT,TEMTAB                NOD00240
820   FORMAT (3A4,I3,1X,A4,12(1X,A4))                                   NOD00250
C                                                                       NOD00260
      DO 120 I=1,12                                                     NOD00270
120     TEMTAB(I) = BLANK                                               NOD00280
      USING = .FALSE.                                                   NOD00290
      IF (MNTHIN .NE. MONTH) GO TO 100                                  NOD00300
      USING = .TRUE.                                                    NOD00310
      LALOUT(1)= LALOIN(1)                                              NOD00320
      LALOUT(2) = LALOIN(2)                                             NOD00330
      LALOUT(3) = LALOIN(3)                                             NOD00340
      IDOUT = IDIN                                                      NOD00350
      GO TO 100                                                         NOD00360
C                                                                       NOD00370
C                                                                       NOD00380
C                                                                       NOD00390
C                                                                       NOD00400
C                                                                       NOD00410
300   IF(.NOT. USING) GO TO 100                                         NOD00420
      IF (ICODE .NE. 3 .AND. ICODE .NE. 4 .AND. ICODE .NE. 6) GO TO 100 NOD00430
      DO 320 I=1,12                                                     NOD00440
        IF(DEPTH .EQ. STDDEP(I)) GO TO 340                              NOD00450
320   CONTINUE                                                          NOD00460
      GO TO 100                                                         NOD00470
340   TEMTAB(I) = TEM                                                   NOD00480
      GO TO 100                                                         NOD00490
C                                                                       NOD00500
C                                                                       NOD00510
C                                                                       NOD00520
```

```
500    WRITE (6,830)
830    FORMAT (' END OF DATA')
       STOP
900    WRITE (6,840)
840    FORMAT (' READ PROBLEM')
       STOP
       END
//GO.FT04F001 DD UNIT=3400-4,VOL=SER=NPS688,DISP=(OLD,KEEP),
//   DCB=(DEN=2,RECFM=FB,LRECL=80,BLKSIZE=3200),LABEL=(1,SL,,IN),
//   DSN=S2514.NDC2
//GO.SYSIN  DD  *
```

```
C
C
C
C               ***************  VELDAT  ***************
C
C
C                SOURCE: A.J. PICKRELL/D.W. YEAGER
C                        NOVEMBER 1978
C
C
C     THIS PROGRAM IS DESIGNED TO READ A SET OF DATA CARDS FOR OCEANO-
C     -GRAPHIC STATIONS CONTAINING SOUND SPEED DATA AT STANDARD DEPTHS
C     (0 TO 400 METERS) FOR EACH STATION AND COMPUTE THE MEAN SOUND
C     SPEED AT THE STANDARD DEPTHS FOR THE SET OF STATIONS SUBMITTED.
C     PROGRAM ALSO COMPUTES STANDARD DEVIATION ( ONE-SIGMA ) OF
C     SOUND SPEEDS AT EACH STANDARD DEPTH AND PRINTS THIS INFORMATION.
C     IN ADDITION, LATITUDE AND LONGITUDE OF STATION HAVING THE
C     MAXIMUM SOUND SPEED VALUE AND THE LATITUDE - LONGITUDE OF
C     THE STATION HAVING THE MINIMUM SOUND SPEED VALUE AT EACH
C     STANDARD DEPTH IS PRINTED.
C
C
C     DATA CARDS ARE GENERATED USING NODPUNA AND CONTAIN LATITUDE,
C     LONGITUDE OF STATION,MONTH OF OBSERVATION,STATION NUMBER,AND
C     LAST 4 DIGITS OF SOUND SPEED VALUE AT EACH STANDARD DEPTH
C     FROM 0 TO 400 METERS.
C     NOTE:  SOUND SPEED VALUE OF 1544.4 METERS/SEC WILL
C     APPEAR ON CARD PRODUCED BY NODPUNA AS  5444. VELDAT
C     ASSUMES THE VALUE  OF 1000 M/SEC IS TO BE ADDED
C     TO ALL SOUND SPEED VALUES ON DATA CARDS.
C
C
C     INPUT CARDS ARE READ IN THE FOLLOWING FORMAT:
C     (I2,F3.1,I3,F3.1,I4,1X,A4,12(1X,F4.1))
C     PLACEMENT OF THE DECIMAL POINT IS ACCOMPLISHED BY INPUT
C     READ FORMAT.
C
C     STATION INPUT MAY BE GROUPED BY MONTH OR OTHER COMBINATION
C     SUCH AS SEASON. IF GROUPED BY MONTH,EACH MONTH'S DATA
C     CARDS MUST HAVE A CARD WITH 99 IN COL. 14 AND 15 AS LAST
C     CARD OF MONTH GROUP. OTHER COMBINATIONS ARE SIMILAR,FOR
C     EXAMPLE; INPUT CARDS FOR MONTHS 1,2,3 GROUPED TOGETHER
C     AS WINTER, A CARD WITH 99 IN COL. 14 AND 15 IS INSERTED AS
C     LAST CARD IN GROUP., AND PRIOR TO NEXT GROUP.
C
C
C     PROGRAM MUST BE MODIFIED TO ACCEPT MORE THAN 150 STATIONS
C     PER GROUP. ARRAYS LATDEG,RLATMN,LONDEG,RLONMN,ID, AND SV
```

```
C         MUST BE DIMENSIONED ACCORDING TO MAXIMUM INPUT CARDS IN A          VEL00490
C         GROUP.                                                             VEL00500
C         INCREMENT IN FIRST "DO" LOOP MUST BE EXTENDED ACCORDINGLY.         VEL00510
C                                                                            VEL00520
C                                                                            VEL00530
          DIMENSION IDEPTH(12), SVMEAN(12), STDDEV(12), NSMPLS(12),          VEL00010
         * SVMAX(12), SVMIN(12), MAXLAD(12), RMXLAM(12), MAXLOD(12),          VEL00020
         * RMXLOM(12),MINLAD(12), RMNLAM(12), MINLOD(12),RMNLOM(12),          VEL00030
         * IDMAX(12), IDMIN(12)                                              VEL00040
          DIMENSION LATDEG(150),RLATMN(150),LONDEG(150),RLONMN(150),
         * ID(150),SV(150,12)
          DATA IDEPTH/0,10,20,30,50,75,100,150,200,250,300,400/              VEL00070
          DATA IBLANK /'    '/                                               VEL00080
          DO 690 MNTH = 1,12                                                 VEL00090
          DO 150 I= 1,150
          READ (5,810) LATDEG(I),RLATMN(I),LONDEG(I),RLONMN(I),MONTH,
         *ID(I),(SV(I,J),J=1,12)                                             VEL00120
810       FORMAT (I2,F3.1,I3,F3.1,I4,1X,A4,12(1X,F4.1))                      VEL00140
          IF(MONTH .GT.12) GO TO 190                                         VEL00130
          DO 120 J = 1,12                                                    VEL00150
          IF(SV(I,J) .NE. 0.0) SV(I,J) = SV(I,J)+1000.0                      VEL00160
120       CONTINUE                                                           VEL00170
150       CONTINUE                                                           VEL00180
190       NSTA = I-1                                                         VEL00190
200       DO 490 J = 1,12                                                    VEL00200
          SVMEAN(J) = 0.0                                                    VEL00210
          STDDEV(J) = 0.0                                                    VEL00220
          NSMPLS(J) = 0                                                      VEL00230
          SVMAX(J) = 0.0                                                     VEL00240
          SVMIN(J) = 1000000.0                                               VEL00250
          MAXLAD(J) =0                                                       VEL00260
          RMXLAM(J) =0.0                                                     VEL00270
          MAXLOD(J) =0                                                       VEL00280
          RMXLOM(J) = 0.0                                                    VEL00290
          MINLAD(J) = 0                                                      VEL00300
          RMNLAM(J) = 0.0                                                    VEL00310
          MINLOD(J) = 0                                                      VEL00320
          RMNLOM(J) =0.0                                                     VEL00330
          IDMAX(J) = IBLANK                                                  VEL00340
          IDMIN(J) = IBLANK                                                  VEL00350
          DO 290 I = 1,NSTA                                                  VEL00370
          IF (SV(I,J) .EQ. 0.0) GO TO 290                                    VEL00380
          NSMPLS(J) = NSMPLS(J)+1                                            VEL00390
          SVMEAN(J) = SVMEAN(J) + SV(I,J)
          IF (SV(I,J) .LT. SVMAX(J)) GO TO 250                               VEL00410
          SVMAX(J)= SV(I,J)                                                  VEL00420
          MAXLAD(J) = LATDEG(I)                                              VEL00430
          RMXLAM(J) = RLATMN(I)                                              VEL00440
```

```
      MAXLOD(J) = LONDEG(I)
      RMXLOM(J) = RLONMN(I)
      IDMAX(J) = ID(I)
250   IF(SV(I,J) .GT. SVMIN(J)) GO TO 290
      SVMIN(J) = SV(I,J)
      MINLAD(J) = LATDEG(I)
      RMNLAM(J) = RLATMN(I)
      MINLOD(J) = LONDEG(I)
      RMNLOM(J) = RLONMN(I)
      IDMIN(J) = ID(I)
290   CONTINUE
300   IF (NSMPLS(J) .LE. 1) GO TO 400
      SVMEAN(J) = SVMEAN(J)/NSMPLS(J)
      SUM = 0.0
      DO 390 I = 1,NSTA
      IF (SV(I,J) .EQ. 0.0) GO TO 390
      SUM = SUM + (SV(I,J)-SVMEAN(J))**2
390   CONTINUE
      STDDEV(J) = SQRT(SUM/(NSMPLS(J)-1))
400   CONTINUE
490   CONTINUE
500   WRITE (6,820) MNTH
820   FORMAT ('1 MONTH = ',I2)
      WRITE (6,830)
830   FORMAT ('0',//,T13,'MEAN SOUND   STANDARD',
     */,T5,'DEPTH   VELOCITY',T26,'DEVIATION  NUMBER OF',
     *T49,'MAXIMUM   MINIMUM   LOCATION   LOCATION',
     *T91,'ID NUMB   ID NUMB',
     */,T6,'(M)      (M/SEC)',T27,'(M/SEC)     SAMPLES',
     *T49,'(M/SEC)   (M/SEC)   OF MAX',
     *T80,'OF MIN     OF MAX    OF MIN')
C
C
C
C
      DO 550 J = 1,12
      WRITE (6,840) IDEPTH(J),SVMEAN(J),STDDEV(J),NSMPLS(J),
     *SVMAX(J),SVMIN(J),MAXLAD(J),RMXLAM(J),MINLAD(J),RMNLAM(J),
     *IDMAX(J),IDMIN(J)
840   FORMAT ('0',T6,I3,T15,F6.1,T28,F6.1,T40,I3,T50,F6.1,
     *T60,F6.1,T69,I3,F5.1,T80,I3,F5.1,T92,A4,T102,A4)
      WRITE (6,850) MAXLOD(J),RMXLOM(J),MINLOD(J),RMNLOM(J)
850   FORMAT (T69,I3,F5.1,T80,I3,F5.1)
550   CONTINUE
C
C
C
690   CONTINUE
```

```
700     WRITE (6,860)                                              VEL00920
860     FORMAT (' END OF DATA')                                    VEL00930
        STOP                                                       VEL00940
        END                                                        VEL00950
```

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C
C               ****************  SALDAT  ****************
C
C
C              SOURCE: A.J. PICKRELL/D.W. YEAGER
C                            NOVEMBER 1978
C
C
C     THIS PROGRAM IS DESIGNED TO READ A SET OF CATA CARDS FOR OCEANO-
C     -GRAPHIC STATIONS CONTAINING SALINITY DATA AT STANDARD DEPTHS
C     (0 TO 400 METERS) FOR EACH STATION AND COMPUTE THE MEAN
C     SALINITY AT THE STANDARD DEPTHS FOR THE SET OF STATIONS SUBMITTED
C     PROGRAM ALSO COMPUTES STANDARD DEVIATION ( ONE-SIGMA ) OF
C     SALINITIES AT EACH STANDARD DEPTH AND PRINTS THIS INFORMATION.
C     IN ADDITION, LATITUDE AND LONGITUDE OF STATION HAVING THE
C     MAXIMUM SALINITY VALUE AND THE LATITUDE - LONGITUDE OF
C     THE STATION HAVING THE MINIMUM SALINITY VALUE AT EACH
C     STANDARD DEPTH IS PRINTED.
C
C
C     DATA CARDS ARE GENERATED USING NODPUNC AND CONTAIN LATITUDE,
C     LONGITUDE OF STATION,MONTH OF OBSERVATION,STATION NUMBER,AND
C     SALINITY VALUES (TO .01 PPT) AT EACH STANDARD DEPTH
C     FROM 0 TO 400 METERS.
C
C
C     INPUT CARDS ARE READ IN THE FOLLOWING FORMAT:
C     (I2,F3.1,I3,F3.1,I4,1X,A4,12(1X,F5.2))
C     PLACEMENT OF THE DECIMAL POINT IS ACCOMPLISHED BY INPUT
C     READ FORMAT.
C
C     STATION INPUT MAY BE GROUPED BY MONTH OR OTHER COMBINATION
C     SUCH AS SEASON. IF GROUPED BY MONTH,EACH MONTH'S DATA
C     CARDS MUST HAVE A CARD WITH 99 IN COL. 14 AND 15 AS LAST
C     CARD OF MONTH GROUP. OTHER COMBINATIONS ARE SIMILAR,FOR
C     EXAMPLE; INPUT CARDS FOR MONTHS 1,2,3 GROUPEC TOGETHER
C     AS WINTER, A CARD WITH 99 IN COL. 14 AND 15 IS INSERTED AS
C     LAST CARD IN GROUP., AND PRIOR TO NEXT GROUP.
C
C
C     PROGRAM MUST BE MODIFIED TO ACCEPT MORE THAN 150 STATIONS
C     PER GROUP. ARRAYS LATDEG,RLATMN,LONDEG,RLONMN,ID, AND SV
C     MUST BE DIMENSIONED ACCORDING TO MAXIMUM INPUT CARDS IN A
C     GROUP.
C     INCREMENT IN FIRST "DO" LOOP MUST BE EXTENDED ACCORDINGLY.
C
C
```

```
C        NOTE: ALTHOUGH TH PARAMETER BEING ANALYZED IS CHANGED,          VEL00500
C        THE VARIABLE NAMES IN THE PROGRAM HAVE NOT BEEN CHANGED         VEL00510
C        FROM VELDAT. ONLY INPUT FORMAT (READ FORMAT) HAS BEEN           VEL00520
C        CHANGED.                                                        VEL00530
C                                                                        VEL00030
      DIMENSION IDEPTH(12), SVMEAN(12), STDDEV(12), NSMPLS(12),          VEL00010
     * SVMAX(12), SVMIN(12), MAXLAD(12), RMXLAM(12), MAXLOD(12),         VEL00020
     * RMXLOM(12),MINLAD(12), RMNLAM(12), MINLOD(12),RMNLOM(12),         VEL00030
     * IDMAX(12), IDMIN(12)                                              VEL00040
      DIMENSION LATDEG(150),RLATMN(150),LONDEG(150),RLONMN(150),
     * ID(150),SV(150,12)
      DATA IDEPTH/0,10,20,30,50,75,100,150,200,250,300,400/              VEL00070
      DATA IBLANK /'    '/                                               VEL00080
      DO 690 MNTH = 1,12                                                 VEL00090
      DO 150 I= 1,150
      READ (5,810) LATDEG(I),RLATMN(I),LONDEG(I),RLONMN(I),MONTH,
     *ID(I),(SV(I,J),J=1,12)                                             VEL00120
810   FORMAT (I2,F3.1,I3,F3.1,I4,1X,A4,12(1X,F4.2))                      VEL00140
      IF(MONTH .GT.12) GO TO 190                                         VEL00130
      DO 120 J = 1,12                                                    VEL00150
      IF(SV(I,J) .NE. 0.0) SV(I,J) = SV(I,J)                             VEL00160
120   CONTINUE                                                           VEL00170
150   CONTINUE                                                           VEL00180
190   NSTA = I-1                                                         VEL00190
200   DO 490 J = 1,12                                                    VEL00200
      SVMEAN(J) = 0.0                                                    VEL00210
      STDDEV(J) = 0.0                                                    VEL00220
      NSMPLS(J) = 0                                                      VEL00230
      SVMAX(J) = 0.0                                                     VEL00240
      SVMIN(J) = 1000000.0                                               VEL00250
      MAXLAD(J) =0                                                       VEL00260
      RMXLAM(J) =0.0                                                     VEL00270
      MAXLOD(J) =0                                                       VEL00280
      RMXLOM(J) = 0.0                                                    VEL00290
      MINLAD(J) = 0                                                      VEL00300
      RMNLAM(J) = 0.0                                                    VEL00310
      MINLOD(J) = 0                                                      VEL00320
      RMNLOM(J) =0.0                                                     VEL00330
      IDMAX(J) = IBLANK                                                  VEL00340
      IDMIN(J) = IBLANK                                                  VEL00350
      DO 290 I = 1,NSTA                                                  VEL00370
      IF (SV(I,J) .EQ. 0.0) GO TO 290                                    VEL00380
      NSMPLS(J) = NSMPLS(J)+1                                            VEL00390
      SVMEAN(J) = SVMEAN(J) + SV(I,J)
      IF (SV(I,J) .LT. SVMAX(J)) GO TO 250                               VEL00410
      SVMAX(J)= SV(I,J)                                                  VEL00420
      MAXLAD(J) = LATDEG(I)                                              VEL00430
      RMXLAM(J) = RLATMN(I)                                              VEL00440
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```
      MAXLOD(J) = LONDEG(I)                                              VEL00450
      RMXLOM(J) = RLONMN(I)                                              VEL00460
      IDMAX(J) = ID(I)                                                   VEL00470
250   IF(SV(I,J) .GT. SVMIN(J)) GO TO 290                                VEL00480
      SVMIN(J) = SV(I,J)                                                 VEL00490
      MINLAD(J) = LATDEG(I)                                              VEL00500
      RMNLAM(J) = RLATMN(I)                                              VEL00510
      MINLOD(J) = LONDEG(I)                                              VEL00520
      RMNLOM(J) = RLONMN(I)                                              VEL00530
      IDMIN(J) = ID(I)                                                   VEL00540
290   CONTINUE                                                           VEL00550
300   IF (NSMPLS(J) .LE. 1) GO TO 400                                    VEL00570
      SVMEAN(J) = SVMEAN(J)/NSMPLS(J)
      SUM = 0.0                                                          VEL00580
      DO 390 I = 1,NSTA                                                  VEL00590
      IF (SV(I,J) .EQ. 0.0) GO TO 390                                    VEL00600
      SUM = SUM + (SV(I,J)-SVMEAN(J))**2
390   CONTINUE                                                           VEL00620
      STDDEV(J) = SQRT(SUM/(NSMPLS(J)-1))                                VEL00630
400   CONTINUE                                                           VEL00640
490   CONTINUE                                                           VEL00650
500   WRITE (6,820) MNTH                                                 VEL00660
820   FORMAT ('1 MONTH = ',I2)                                           VEL00670
      WRITE (6,830)                                                      VEL00680
830   FORMAT ('0',1X,T13,'MEAN            STANDARD',                     VEL00690
     */,T5,'DEPTH   SALINITY',T26,'DEVIATION  NUMBER OF',                VEL00700
     *T49,'MAXIMUM    MINIMUM    LOCATION   LOCATION',                   VEL00710
     *T91,'ID NUMB   ID NUMB',                                           VEL00720
     */,T6,'(M)      ( PPT )',T27,'( PPT )    SAMPLES',                  VEL00730
     *T49,'( PPT )    ( PPT )   OF MAX',                                 VEL00740
     *T80,'OF MIN     OF MAX    OF MIN')                                 VEL00750
C                                                                        VEL00760
C                                                                        VEL00770
C                                                                        VEL00780
C                                                                        VEL00790
      DO 550 J = 1,12                                                    VEL00800
      WRITE (6,840) IDEPTH(J),SVMEAN(J),STDDEV(J),NSMPLS(J),             VEL00810
     *SVMAX(J),SVMIN(J),MAXLAD(J),RMXLAM(J),MINLAD(J),RMNLAM(J),
     *IDMAX(J),IDMIN(J)
840   FORMAT ('0',T6,I3,T15,F6.2,T28,F6.2,T40,I3,T50,F6.2,               VEL00830
     *T60,F6.2,T69,I3,F5.1,T80,I3,F5.1,T92,A4,T102,A4)                   VEL00840
      WRITE (6,850) MAXLOD(J),RMXLOM(J),MINLOD(J),RMNLOM(J)              VEL00850
850   FORMAT (T69,I3,F5.1,T80,I3,F5.1)                                   VEL00860
550   CONTINUE                                                           VEL00870
C                                                                        VEL00880
C                                                                        VEL00890
C                                                                        VEL00900
690   CONTINUE                                                           VEL00910
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```
700    WRITE (6,860)                                                    VEL00920
860    FORMAT (' END OF DATA')                                          VEL00930
       STOP                                                             VEL00940
       END                                                              VEL00950
```

```
C
C
C                ***************  TEMDAT   ***************
C
C
C                SOURCE:  A.J. PICKRELL/D.W. YEAGER
C                         NOVEMBER 1978
C
C
C     THIS PROGRAM IS DESIGNED TO READ A SET OF DATA CARDS FOR OCEANO-
C     -GRAPHIC STATIONS CONTAINING TEMPERATURE DATA AT STANDARD DEPTHS
C     (0 TO 400 METERS) FOR EACH STATION AND COMPUTE THE MEAN TEM-
C     PERATURE AT THE STANDARD DEPTHS FOR THE SET OF STATIONS SUBMITTED
C     PROGRAM ALSO COMPUTES STANDARD DEVIATION ( ONE-SIGMA ) OF
C     TEMPERATURES AT EACH STANDARD DEPTH AND PRINTS THIS INFORMATION.
C     IN ADDITION, LATITUDE AND LONGITUDE OF STATION HAVING THE
C     MAXIMUM TEMPERATURE VALUE AND THE LATITUDE - LONGITUDE OF
C     THE STATION HAVING THE MINIMUM TEMPERATURE VALUE AT EACH
C     STANDARD DEPTH IS PRINTED.
C
C
C     DATA CARDS ARE GENERATED USING NODPUNB AND CONTAIN LATITUDE,
C     LONGITUDE OF STATION,MONTH OF OBSERVATION,STATION NUMBER,AND
C     TEMPERATURE VALUES (TO .01 DEG-C) AT EACH STANDARD DEPTH
C     FROM 0 TO 400 METERS.
C
C
C     INPUT CARDS ARE READ IN THE FOLLOWING FORMAT:
C     (I2,F3.1,I3,F3.1,I4,1X,A4,12(1X,F5.2))
C     PLACEMENT OF THE DECIMAL POINT IS ACCOMPLISHED BY INPUT
C     READ FORMAT.
C
C     STATION INPUT MAY BE GROUPED BY MONTH OR OTHER COMBINATION
C     SUCH AS SEASON. IF GROUPED BY MONTH,EACH MONTH'S DATA
C     CARDS MUST HAVE A CARD WITH 99 IN COL. 14 AND 15 AS LAST
C     CARD OF MONTH GROUP. OTHER COMBINATIONS ARE SIMILAR,FOR
C     EXAMPLE; INPUT CARDS FOR MONTHS 1,2,3 GROUPED TOGETHER
C     AS WINTER, A CARD WITH 99 IN COL. 14 AND 15 IS INSERTED AS
C     LAST CARD IN GROUP., AND PRIOR TO NEXT GROUP.
C
C
C     PROGRAM MUST BE MODIFIED TO ACCEPT MORE THAN 150 STATIONS
C     PER GROUP. ARRAYS LATDEG,RLATMN,LONDEG,RLONMN,ID, AND SV
C     MUST BE DIMENSIONED ACCORDING TO MAXIMUM INPUT CARDS IN A
C     GROUP.
C      INCREMENT IN FIRST "DO" LOOP MUST BE EXTENDED ACCORDINGLY.
C
C
```

```
C       NOTE: ALTHOUGH TH PARAMETER BEING ANALYZED IS CHANGED,          VEL00500
C       THE VARIABLE NAMES IN THE PROGRAM HAVE NOT BEEN CHANGED         VEL00510
C       FROM VELDAT. ONLY INPUT FORMAT (READ FORMAT) HAS BEEN           VEL00520
C       CHANGED.                                                        VEL00530
C                                                                       VEL00010
      DIMENSION IDEPTH(12), SVMEAN(12), STDDEV(12), NSMPLS(12),         VEL00010
     * SVMAX(12), SVMIN(12), MAXLAD(12), RMXLAM(12), MAXLOD(12),        VEL00020
     * RMXLOM(12),MINLAD(12), RMNLAM(12), MINLOD(12),RMNLOM(12),        VEL00030
     * IDMAX(12), IDMIN(12)                                             VEL00040
      DIMENSION LATDEG(150),RLATMN(150),LONDEG(150),RLONMN(150),
     * ID(150),SV(150,12)
      DATA IDEPTH/0,10,20,30,50,75,100,150,200,250,300,400/             VEL00070
      DATA IBLANK /'    '/                                              VEL00080
      DO 690  MNTH = 1,12                                               VEL00090
      DO 150 I= 1,150
      READ (5,810) LATDEG(I),RLATMN(I),LONDEG(I),RLONMN(I),MONTH,       VEL00110
     *ID(I),(SV(I,J),J=1,12)                                            VEL00120
      IF(MONTH .GT.12) GO TO 190                                        VEL00130
810   FORMAT (I2,F3.1,I3,F3.1,I4,1X,A4,12(1X,F4.2))                     VEL00140
      DO 120 J = 1,12                                                   VEL00150
      IF(SV(I,J) .NE. 0.0) SV(I,J) = SV(I,J)                            VEL00160
120   CONTINUE                                                          VEL00170
150   CONTINUE                                                          VEL00180
190   NSTA = I-1                                                        VEL00190
200   DO 490 J = 1,12                                                   VEL00200
      SVMEAN(J) = 0.0                                                   VEL00210
      STDDEV(J) = 0.0                                                   VEL00220
      NSMPLS(J) = 0                                                     VEL00230
      SVMAX(J) = 0.0                                                    VEL00240
      SVMIN(J) = 1000000.0                                              VEL00250
      MAXLAD(J) =0                                                      VEL00260
      RMXLAM(J) =0.0                                                    VEL00270
      MAXLOD(J) =0                                                      VEL00280
      RMXLOM(J) = 0.0                                                   VEL00290
      MINLAD(J) = 0                                                     VEL00300
      RMNLAM(J) = 0.0                                                   VEL00310
      MINLOD(J) = 0                                                     VEL00320
      RMNLOM(J) =0.0                                                    VEL00330
      IDMAX(J) = IBLANK                                                 VEL00340
      IDMIN(J) = IBLANK                                                 VEL00350
      DO 290 I = 1,NSTA                                                 VEL00360
      IF (SV(I,J) .EQ. 0.0) GO TO 290                                   VEL00370
      NSMPLS(J) = NSMPLS(J)+1                                           VEL00380
      SVMEAN(J) = SVMEAN(J) + SV(I,J)                                   VEL00390
      IF (SV(I,J) .LT. SVMAX(J)) GO TO 250                              VEL00400
      SVMAX(J)= SV(I,J)                                                 VEL00410
      MAXLAD(J) = LATDEG(I)                                             VEL00420
      RMXLAM(J) = RLATMN(I)                                             VEL00430
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      MAXLOD(J) = LONDEG(I)
      RMXLOM(J) = RLONMN(I)
      IDMAX(J) = ID(I)
250   IF(SV(I,J) .GT. SVMIN(J)) GO TO 290
      SVMIN(J) = SV(I,J)
      MINLAD(J) = LATDEG(I)
      RMNLAM(J) = RLATMN(I)
      MINLOD(J) = LONDEG(I)
      RMNLOM(J) = RLONMN(I)
      IDMIN(J) = ID(I)
290   CONTINUE
300   IF (NSMPLS(J) .LE. 1) GO TO 400
      SVMEAN(J) = SVMEAN(J)/NSMPLS(J)
      SUM = 0.0
      DO 390 I = 1,NSTA
      IF (SV(I,J) .EQ. 0.0) GO TO 390
      SUM = SUM + (SV(I,J)-SVMEAN(J))**2
390   CONTINUE
      STDDEV(J) = SQRT(SUM/(NSMPLS(J)-1))
400   CONTINUE
490   CONTINUE
500   WRITE (6,820) MNTH
820   FORMAT ('1 MONTH = ',I2)
      WRITE (6,830)
830   FORMAT ('0',1X,T13,'MEAN            STANDARD',
     */,T5,'DEPTH       TEMP.',T26,'DEVIATION  NUMBER OF',
     *T49,'MAXIMUM   MINIMUM   LOCATION   LOCATION',
     *T91,'ID NUMB   ID NUMB',
     */,T6,'(M)      (DEG-C)',T27,'(DEG-C)     SAMPLES',
     *T49,'(DEG-C)   (DEG-C)   OF MAX',
     *T80,'OF MIN      OF MAX     OF MIN')
C
C
C
C
      DO 550 J = 1,12
      WRITE (6,840) IDEPTH(J),SVMEAN(J),STDDEV(J),NSMPLS(J),
     *SVMAX(J),SVMIN(J),MAXLAD(J),RMXLAM(J),MINLAD(J),RMNLAM(J),
     *IDMAX(J),IDMIN(J)
840   FORMAT ('0',T6,I3,T15,F6.2,T28,F6.2,T40,I3,T50,F6.2,
     *T60,F6.2,T69,I3,F5.1,T80,I3,F5.1,T92,A4,T102,A4)
      WRITE (6,850) MAXLOD(J),RMXLOM(J),MINLOD(J),RMNLOM(J)
850   FORMAT (T69,I3,F5.1,T80,I3,F5.1)
550   CONTINUE
C
C
C
690   CONTINUE
```

```
700    WRITE (6,860)                                              VEL00920
860    FORMAT (' END OF DATA')                                    VEL00930
       STOP                                                       VEL00940
       END                                                        VEL00950
```

Appendix 2:

VELDAT Results

WINTER - REGION II

DEPTH (M)	MEAN SOUND VELOCITY (M/SEC)	STANDARD DEVIATION (M/SEC)	NUMBER OF SAMPLES	MAXIMUM (M/SEC)	MINIMUM (M/SEC)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	1521.5	5.4	39	1531.3	1507.7	32 7.8 79 5.0	32 5.3 79 32.4	61	49
10	1521.1	5.3	40	1529.6	1507.5	32 7.8 79 5.0	32 51.3 78 43.4	61	45
20	1521.3	4.9	37	1529.6	1508.0	32 7.8 79 5.0	32 5.3 79 32.4	61	49
30	1522.2	4.9	26	1528.8	1507.9	32 7.8 79 5.0	32 5.3 79 32.4	61	49
50	1521.6	4.5	19	1527.8	1510.4	32 7.8 79 5.0	32 20.0 79 0.0	61	42
75	1520.5	4.4	14	1526.6	1512.1	32 7.8 79 5.0	32 38.6 78 34.0	61	44
100	1517.9	5.7	7	1523.6	1507.7	32 9.1 79 3.2	32 7.8 79 6.0	29	60
150	1513.0	1.8	2	1514.3	1511.8	32 26.0 78 42.0	32 14.0 78 58.0	41	74
200	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

SPRING - REGION II

DEPTH (M)	MEAN SOUND VELOCITY (M/SEC)	STANDARD DEVIATION (M/SEC)	NUMBER OF SAMPLES	MAXIMUM (M/SEC)	MINIMUM (M/SEC)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	1524.0	4.2	31	1534.8	1514.5	32 33.0 78 34.0	32 28.0 79 36.0	59	2
10	1523.9	4.1	28	1534.7	1514.1	32 33.0 78 34.0	32 28.0 79 36.0	59	2
20	1523.6	3.6	25	1531.7	1518.2	32 33.0 78 34.0	32 40.0 79 0.0	59	47
30	1523.7	4.1	21	1535.7	1517.9	32 13.0 79 2.0	32 19.0 79 9.0	595	56
50	1521.4	2.8	10	1526.7	1517.9	32 13.0 79 2.0	32 11.0 79 10.0	595	55
75	1518.7	2.6	8	1522.8	1515.4	32 55.0 78 8.0	32 2.0 79 14.0	70	54
100	1514.4	3.2	5	1519.1	1511.3	32 38.0 78 30.0	32 13.0 79 2.0	99	595
150	1516.5	0.0	1	1516.5	1516.5	32 38.0 78 30.0	32 36.0 78 30.0	99	99
200	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

SUMMER - REGION II

DEPTH (M)	MEAN SOUND VELOCITY (M/SEC)	STANDARD DEVIATION (M/SEC)	NUMBER OF SAMPLES	MAXIMUM (M/SEC)	MINIMUM (M/SEC)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	1541.7	1.7	77	1545.4	1536.0	32 7.6 79 31.9	32 14.0 79 7.0	35	2
10	1541.0	1.8	78	1544.4	1533.4	32 30.0 79 0.0	32 14.0 79 7.0	4	2
20	1538.8	3.3	67	1544.2	1523.8	32 34.6 78 38.8	32 14.0 79 7.0	23	2
30	1534.6	5.4	48	1540.4	1516.4	32 13.0 79 9.2	32 14.0 79 7.0	31	2
50	1530.2	6.0	25	1538.0	1514.4	32 3.2 79 23.5	32 14.0 79 7.0	86	2
75	1523.6	7.0	10	1534.0	1512.0	32 12.2 79 0.8	32 24.0 78 45.0	11	45
100	1515.6	11.1	6	1531.2	1499.1	32 12.2 79 0.8	32 24.0 78 45.0	11	45
150	1499.3	10.8	4	1508.4	1484.4	32 26.0 78 43.0	32 24.0 78 45.0	48	45
200	1494.2	14.4	2	1504.4	1484.0	32 26.0 78 43.0	32 24.0 78 45.0	48	45
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

AUTUMN - REGION II

DEPTH (M)	MEAN SOUND VELOCITY (M/SEC)	STANDARD DEVIATION (M/SEC)	NUMBER OF SAMPLES	MAXIMUM (M/SEC)	MINIMUM (M/SEC)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	1533.9	4.5	33	1540.0	1523.3	32 37.0 78 32.0	32 12.0 79 33.0	64	39
10	1534.0	4.4	33	1539.6	1523.5	32 13.0 79 9.0	32 12.0 79 33.0	57	39
20	1533.8	4.5	33	1539.5	1523.2	32 13.0 79 9.0	32 40.0 79 0.0	57	43
30	1535.1	3.3	18	1539.6	1528.5	32 13.0 79 9.0	32 12.7 79 10.8	57	57
50	1536.5	3.0	6	1538.9	1530.7	32 29.0 78 48.0	32 10.0 79 7.0	63	32
75	1533.2	7.5	5	1537.8	1519.9	32 12.0 79 6.0	32 10.0 79 7.0	60	32
100	1527.8	13.8	3	1537.3	1512.0	32 25.0 78 44.0	32 10.0 79 7.0	47	32
150	1512.7	5.8	2	1516.8	1508.6	32 25.0 78 44.0	32 10.0 79 7.0	47	32
200	1505.7	0.0	1	1505.7	1505.7	32 10.0 79 7.0	32 10.0 79 7.0	32	32
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

WINTER - REGION II

DEPTH (M)	MEAN TEMP. (DEG-C)	STANDARD DEVIATION (DEG-C)	NUMBER OF SAMPLES	MAXIMUM (DEG-C)	MINIMUM (DEG-C)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	19.24	1.89	40	22.91	14.71	32 7.8 79 5.0	32 51.3 78 43.4	61	45
10	19.05	1.84	40	22.17	14.53	32 7.8 79 5.0	32 51.3 78 43.4	61	45
20	19.14	1.70	38	22.09	14.69	32 7.8 79 5.0	32 5.3 79 32.4	61	49
30	19.35	1.69	26	21.72	14.60	32 7.8 79 5.0	32 5.3 79 32.4	61	49
50	19.01	1.53	19	21.19	15.31	32 7.8 79 5.0	32 20.0 79 0.0	61	42
75	18.26	1.69	15	20.57	15.06	32 7.8 79 5.0	32 20.0 79 0.0	61	42
100	17.46	1.81	7	19.34	14.23	32 9.1 79 3.2	32 7.8 79 6.0	29	60
150	15.57	0.56	2	15.97	15.18	32 26.0 78 42.0	32 14.0 78 58.0	41	74
200	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

SPRING - REGION II

DEPTH (M)	MEAN TEMP. (DEG-C)	STANDARD DEVIATION (DEG-C)	NUMBER OF SAMPLES	MAXIMUM (DEG-C)	MINIMUM (DEG-C)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	20.63	1.72	33	24.86	17.30	32 13.0 79 2.0	32 28.0 79 36.0	595	2
10	20.49	1.75	30	25.16	17.12	32 13.0 79 2.0	32 28.0 79 36.0	595	2
20	20.15	1.71	26	25.47	18.06	32 13.0 79 2.0	32 40.0 79 0.0	595	47
30	19.90	1.56	21	24.62	17.86	32 13.0 79 2.0	32 19.0 79 9.0	595	56
50	18.90	1.03	10	20.90	17.68	32 13.0 79 2.0	32 11.0 79 10.0	595	55
75	17.81	0.87	8	19.21	16.73	32 55.0 78 8.0	32 2.0 79 14.0	70	54
100	16.25	0.97	5	17.70	15.32	32 38.0 78 30.0	32 13.0 79 2.0	99	595
150	16.56	0.0	1	16.56	16.56	32 38.0 78 30.0	32 38.0 78 30.0	99	99
200	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

SUMMER - REGION II

DEPTH (M)	MEAN TEMP. (DEG-C)	STANDARD DEVIATION (DEG-C)	NUMBER OF SAMPLES	MAXIMUM (DEG-C)	MINIMUM (DEG-C)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	27.74	0.78	78	29.32	25.01	32 7.6 79 31.9	32 14.0 79 7.0	35	2
10	27.32	0.84	78	28.70	23.79	32 30.0 79 0.0	32 14.0 79 7.0	4	2
20	26.16	1.39	68	28.50	20.00	32 34.6 78 38.8	32 14.0 79 7.0	23	2
30	24.23	2.19	48	26.81	17.37	32 0.5 79 17.0	32 14.0 79 7.0	22	2
50	22.31	2.31	25	25.43	16.57	32 3.2 79 23.5	32 14.0 79 7.0	86	2
75	19.69	2.45	10	23.40	15.76	32 12.2 79 0.8	32 24.0 78 45.0	11	45
100	16.94	3.58	6	22.06	11.82	32 12.2 79 0.8	32 24.0 78 45.0	11	45
150	11.76	2.91	4	14.27	7.76	32 26.0 78 43.0	32 24.0 78 45.0	48	45
200	10.15	3.83	2	12.86	7.45	32 26.0 78 43.0	32 24.0 78 45.0	48	45
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

AUTUMN - REGION II

DEPTH (M)	MEAN TEMP. (DEG-C)	STANDARD DEVIATION (DEG-C)	NUMBER OF SAMPLES	MAXIMUM (DEG-C)	MINIMUM (DEG-C)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	24.09	1.81	33	26.50	19.84	32 37.0 78 32.0	32 12.0 79 33.0	64	39
10	24.03	1.78	33	26.41	19.87	32 13.0 79 9.0	32 12.0 79 33.0	57	39
20	23.90	1.84	33	26.29	19.67	32 13.0 79 9.0	32 40.0 79 0.0	57	43
30	24.32	1.35	18	26.25	21.65	32 13.0 79 9.0	32 12.7 79 10.8	57	57
50	24.73	1.20	6	25.71	22.46	32 29.0 78 48.0	32 10.0 79 7.0	63	32
75	23.29	2.84	5	25.08	18.31	32 12.0 79 6.0	32 10.0 79 7.0	60	32
100	21.17	4.91	3	24.70	15.56	32 25.0 78 44.0	32 10.0 79 7.0	47	32
150	15.50	1.73	2	16.73	14.28	32 25.0 78 44.0	32 10.0 79 7.0	47	32
200	13.21	0.0	1	13.21	13.21	32 10.0 79 7.0	32 10.0 79 7.0	32	32
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

WINTER - REGION II

DEPTH (M)	MEAN SALINITY (PPT)	STANDARD DEVIATION (PPT)	NUMBER OF SAMPLES	MAXIMUM (PPT)	MINIMUM (PPT)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	36.29	0.10	39	36.47	36.01	32 22.0 79 15.0	32 5.3 79 32.4	1	49
10	36.28	0.10	40	36.46	36.01	32 22.0 79 15.0	32 5.3 79 32.4	1	49
20	36.24	0.32	38	36.45	34.43	32 22.0 79 15.0	32 12.1 79 11.2	1	2
30	36.28	0.12	26	36.44	36.02	32 12.1 79 11.2	32 5.3 79 32.4	2	49
50	36.29	0.14	19	36.55	36.02	32 7.4 79 5.9	32 20.0 79 0.0	3	42
75	36.27	0.14	14	36.46	36.00	32 7.4 79 5.9	32 14.0 78 58.0	3	74
100	36.24	0.20	7	36.42	35.88	32 9.1 79 3.2	32 7.8 79 6.0	29	60
150	36.12	0.04	2	36.15	36.09	32 26.0 78 42.0	32 14.0 78 58.0	41	74
200	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

SPRING - REGION II

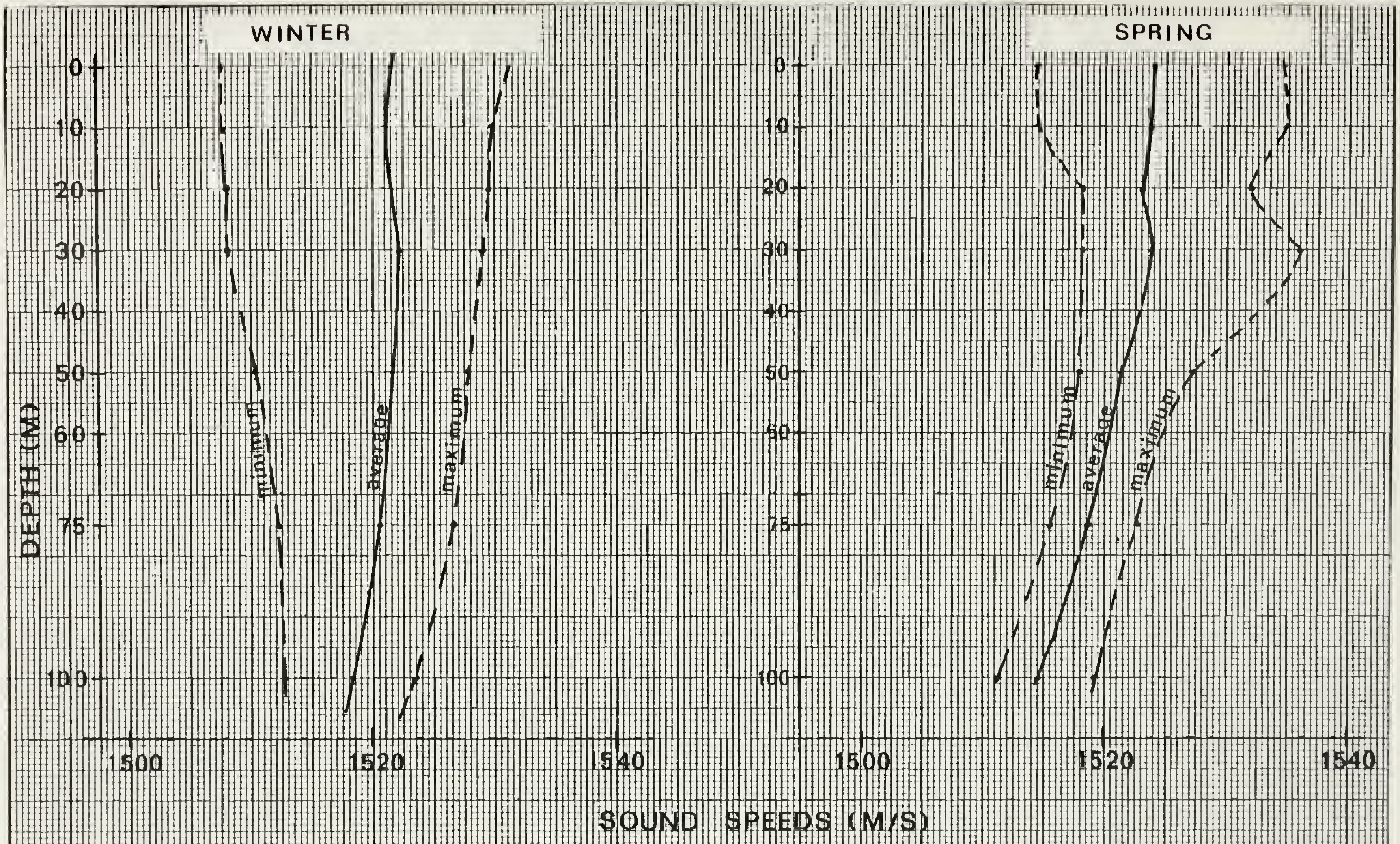
DEPTH (M)	MEAN SALINITY (PPT)	STANDARD DEVIATION (PPT)	NUMBER OF SAMPLES	MAXIMUM (PPT)	MINIMUM (PPT)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	35.72	0.77	32	36.63	33.87	32 46.0 78 30.0	32 35.0 79 27.0	98	597
10	35.86	0.61	28	36.63	34.39	32 46.0 78 30.0	32 35.0 79 27.0	98	597
20	36.14	0.23	25	36.62	35.67	32 46.0 78 30.0	32 24.0 79 15.0	98	596
30	36.22	0.21	21	36.62	35.69	32 46.0 78 30.0	32 24.0 79 15.0	98	596
50	36.29	0.15	10	36.54	36.09	32 38.0 78 30.0	32 20.0 78 58.0	99	94
75	36.28	0.18	8	36.52	35.99	32 38.0 78 30.0	32 20.0 78 58.0	99	94
100	36.19	0.29	5	36.51	35.88	32 38.0 78 30.0	32 20.0 78 58.0	99	94
150	36.49	0.0	1	36.49	36.49	32 38.0 78 30.0	32 38.0 78 30.0	99	99
200	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

SUMMER - REGION II

DEPTH (M)	MEAN SALINITY (PPT)	STANDARD DEVIATION (PPT)	NUMBER OF SAMPLES	MAXIMUM (PPT)	MINIMUM (PPT)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	35.60	0.53	77	36.58	33.08	32 26.0 78 43.0	32 30.0 79 10.0	48	8
10	35.68	0.48	78	36.42	33.36	32 12.2 79 0.8	32 30.0 79 10.0	11	8
20	35.92	0.32	67	36.45	34.43	32 12.2 79 0.8	32 30.0 79 10.0	11	8
30	36.12	0.21	48	36.48	35.45	32 12.2 79 0.8	32 9.5 79 30.1	11	23
50	36.18	0.21	25	36.54	35.55	32 12.2 79 0.8	32 13.2 79 0.0	11	90
75	36.09	0.38	10	36.63	35.42	32 8.7 79 10.5	32 13.2 79 0.0	12	90
100	35.87	0.50	6	36.70	35.29	32 12.2 79 0.8	32 13.2 79 0.0	11	90
150	35.44	0.35	4	35.71	34.97	32 26.0 78 43.0	32 24.0 78 45.0	48	45
200	35.28	0.47	2	35.62	34.95	32 26.0 78 43.0	32 24.0 78 45.0	48	45
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		

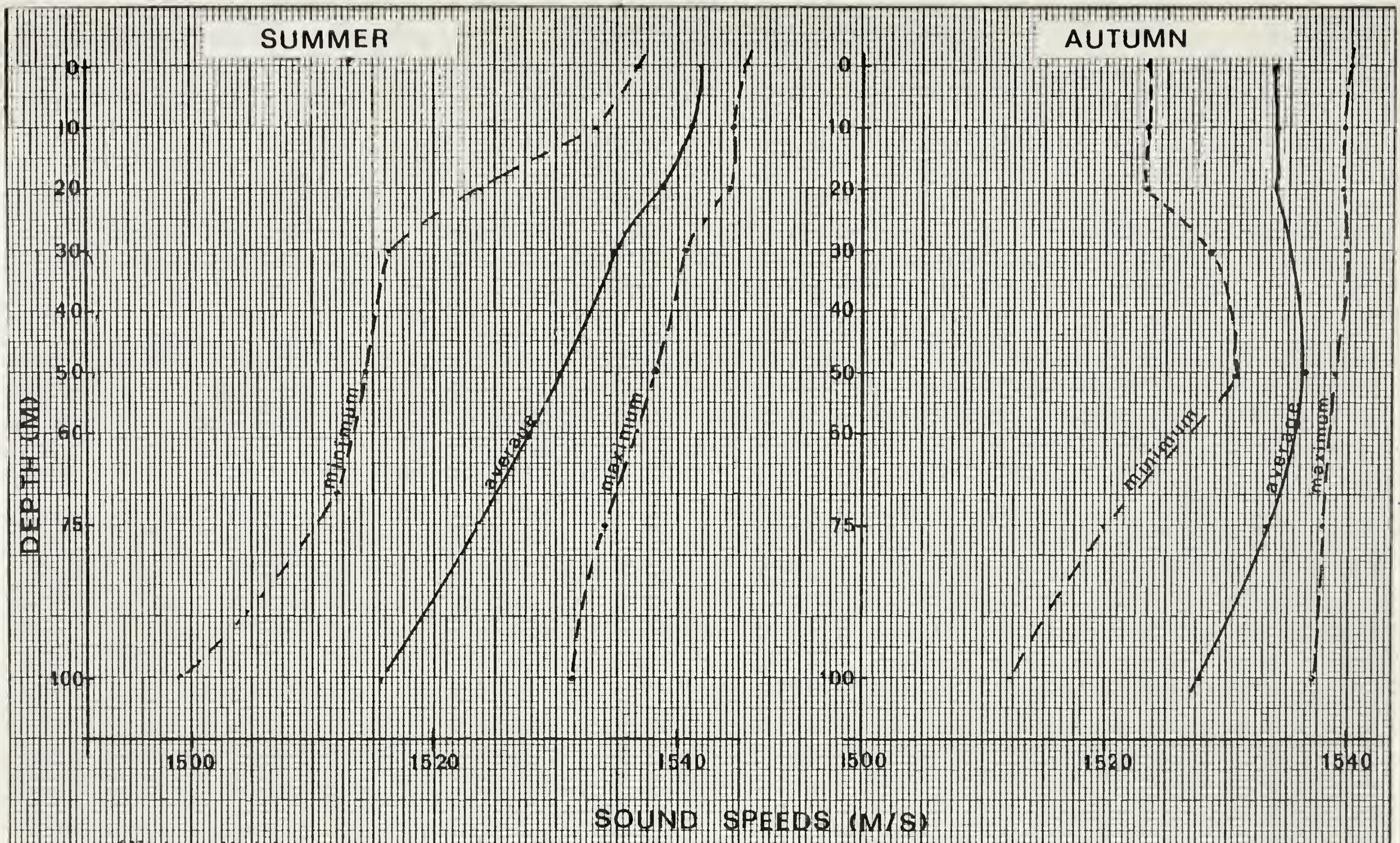
AUTUMN - REGION II

DEPTH (M)	MEAN SALINITY (PPT)	STANDARD DEVIATION (PPT)	NUMBER OF SAMPLES	MAXIMUM (PPT)	MINIMUM (PPT)	LOCATION OF MAX	LOCATION OF MIN	ID NUMB OF MAX	ID NUMB OF MIN
0	36.25	0.17	33	36.52	35.46	32 37.0 78 32.0	32 49.0 78 44.0	64	67
10	36.25	0.13	33	36.54	35.81	32 37.0 78 32.0	32 49.0 78 44.0	64	67
20	36.26	0.10	33	36.55	36.09	32 37.0 78 32.0	32 22.0 79 14.0	64	29
30	36.26	0.12	18	36.57	36.11	32 37.0 78 32.0	32 10.0 79 7.0	64	32
50	36.34	0.18	6	36.60	36.09	32 37.0 78 32.0	32 10.0 79 7.0	64	32
75	36.35	0.21	5	36.64	36.05	32 37.0 78 32.0	32 10.0 79 7.0	64	32
100	36.36	0.34	3	36.67	36.00	32 37.0 78 32.0	32 10.0 79 7.0	64	32
150	36.09	0.34	2	36.33	35.85	32 25.0 78 44.0	32 10.0 79 7.0	47	32
200	35.69	0.0	1	35.69	35.69	32 10.0 79 7.0	32 10.0 79 7.0	32	32
250	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
300	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		
400	0.0	0.0	0	0.0	******	0 0.0 0 0.0	0 0.0 0 0.0		



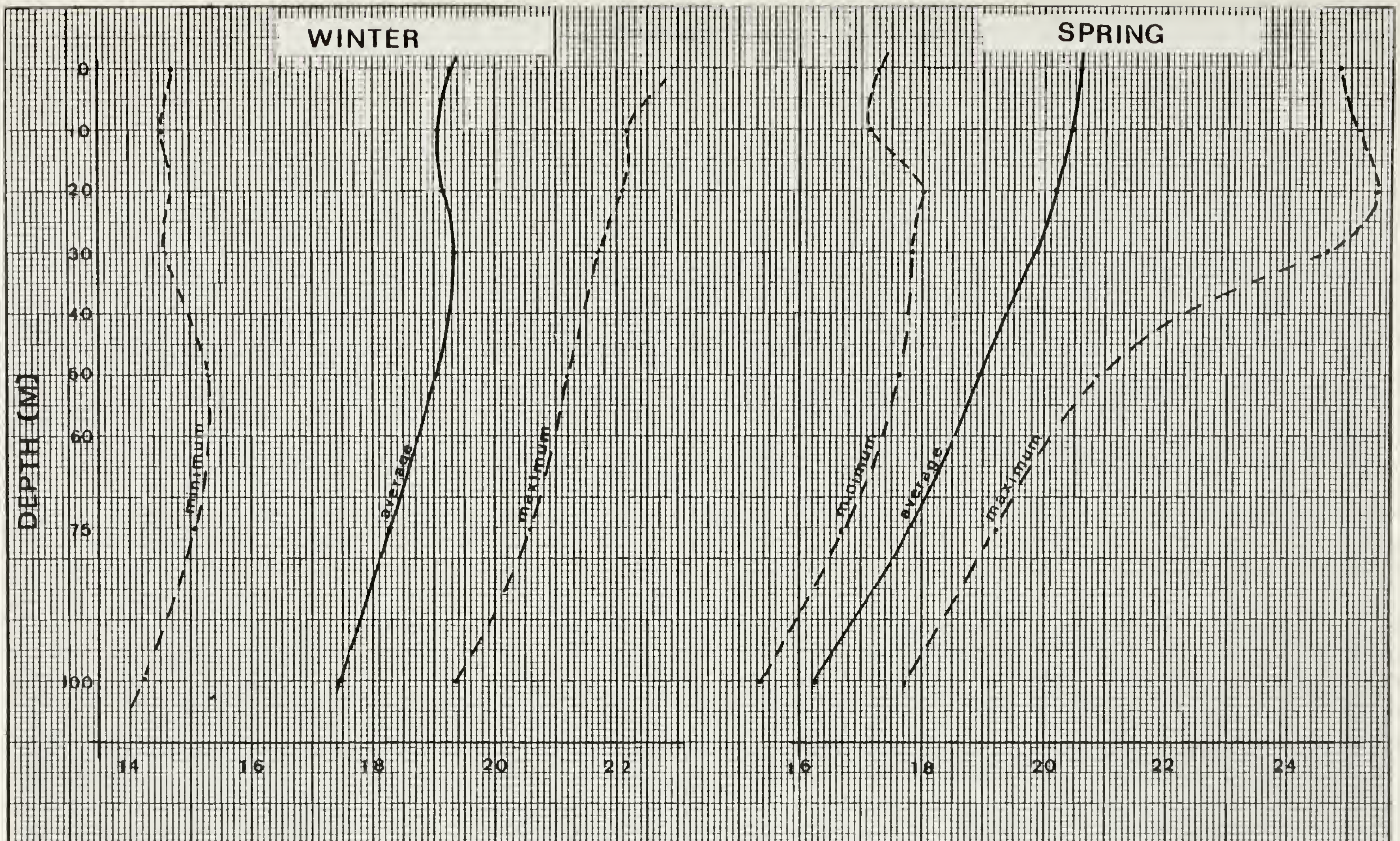
(Note: Maximum and minimum profiles represent composites of all stations)

VEDLAT PROFILES - REGION II



(Note: Maximum and minimum profiles represent composites for all stations)

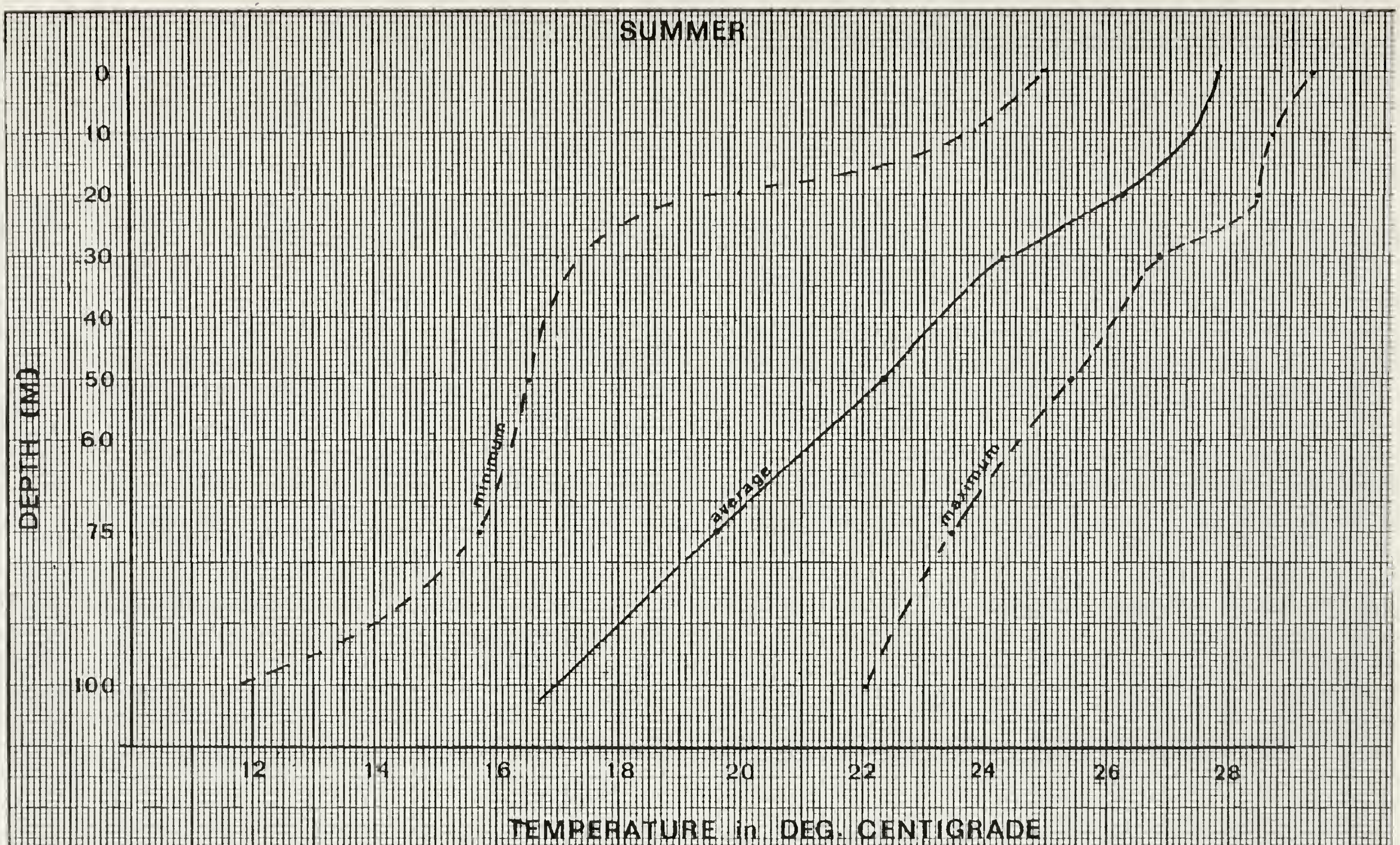
VELLAT PROFILES – REGION II



TEMPERATURE in DEG. CENTIGRADE

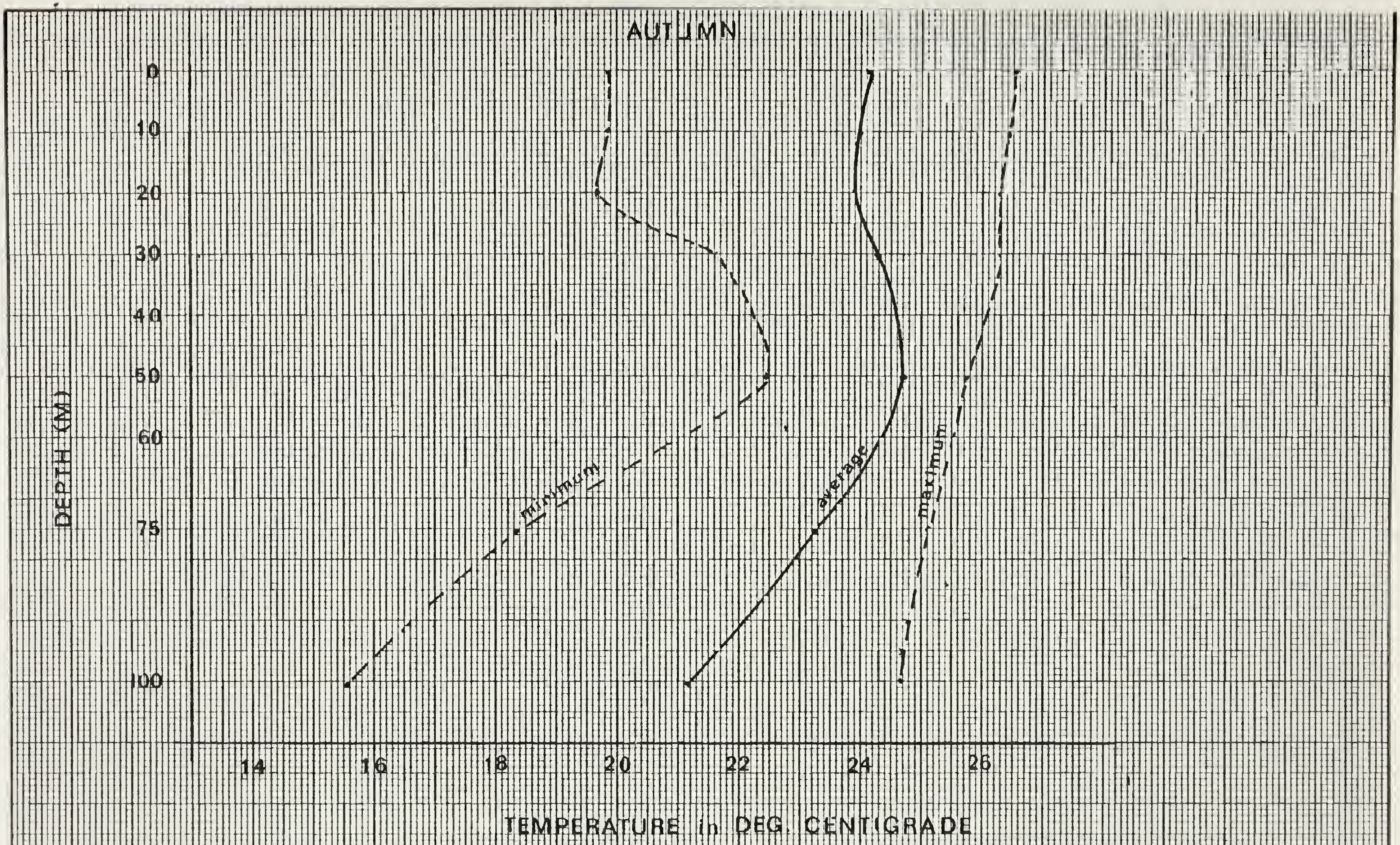
(Note: Maximum and minimum curves represent composites of all stations)

TEMDAT PROFILES - REGION II



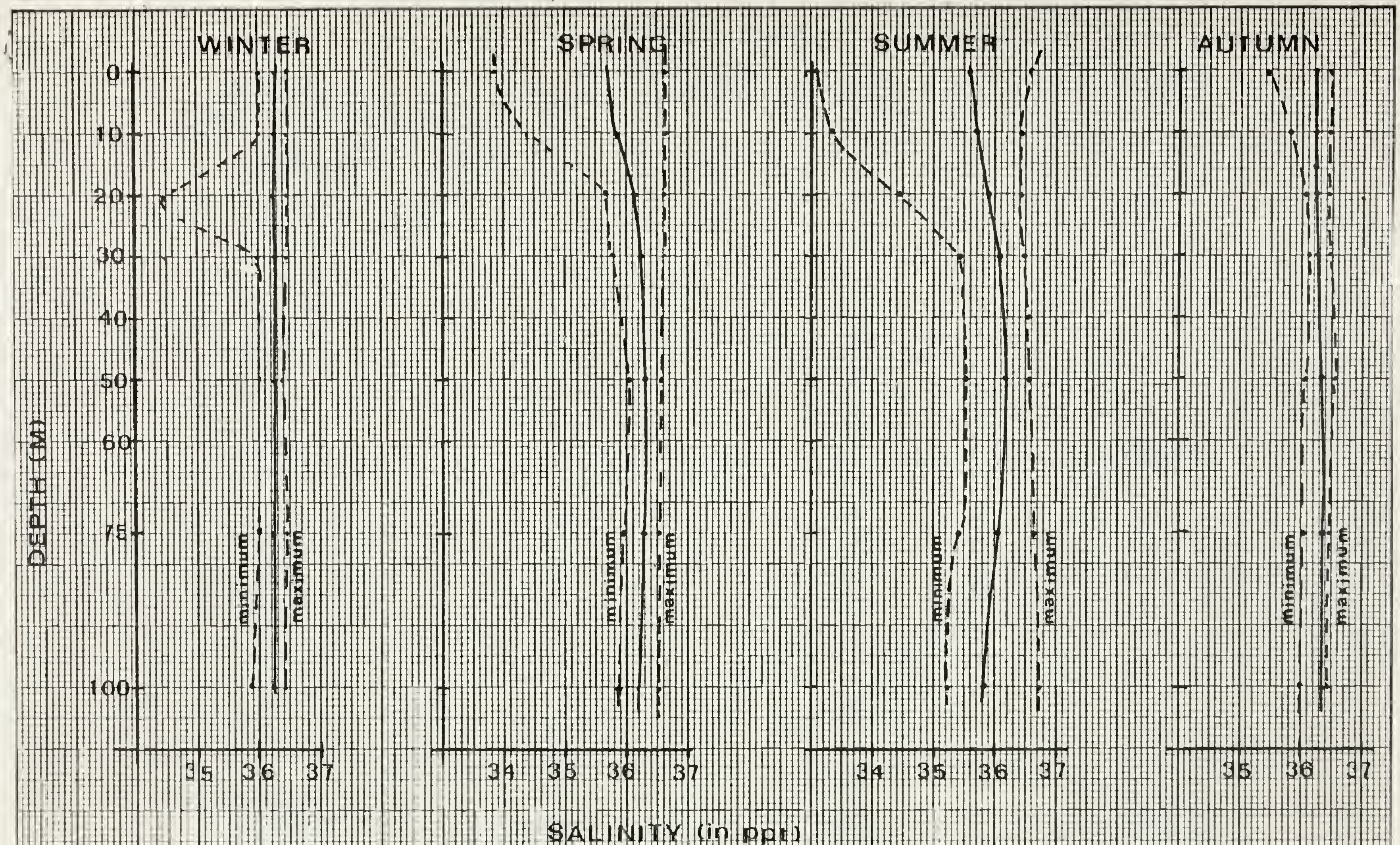
(Note: Maximum and minimum profiles represent composites of all stations)

TEMDAT PROFILES - REGION II



(Note: Maximum and minimum profiles represent composites of all stations)

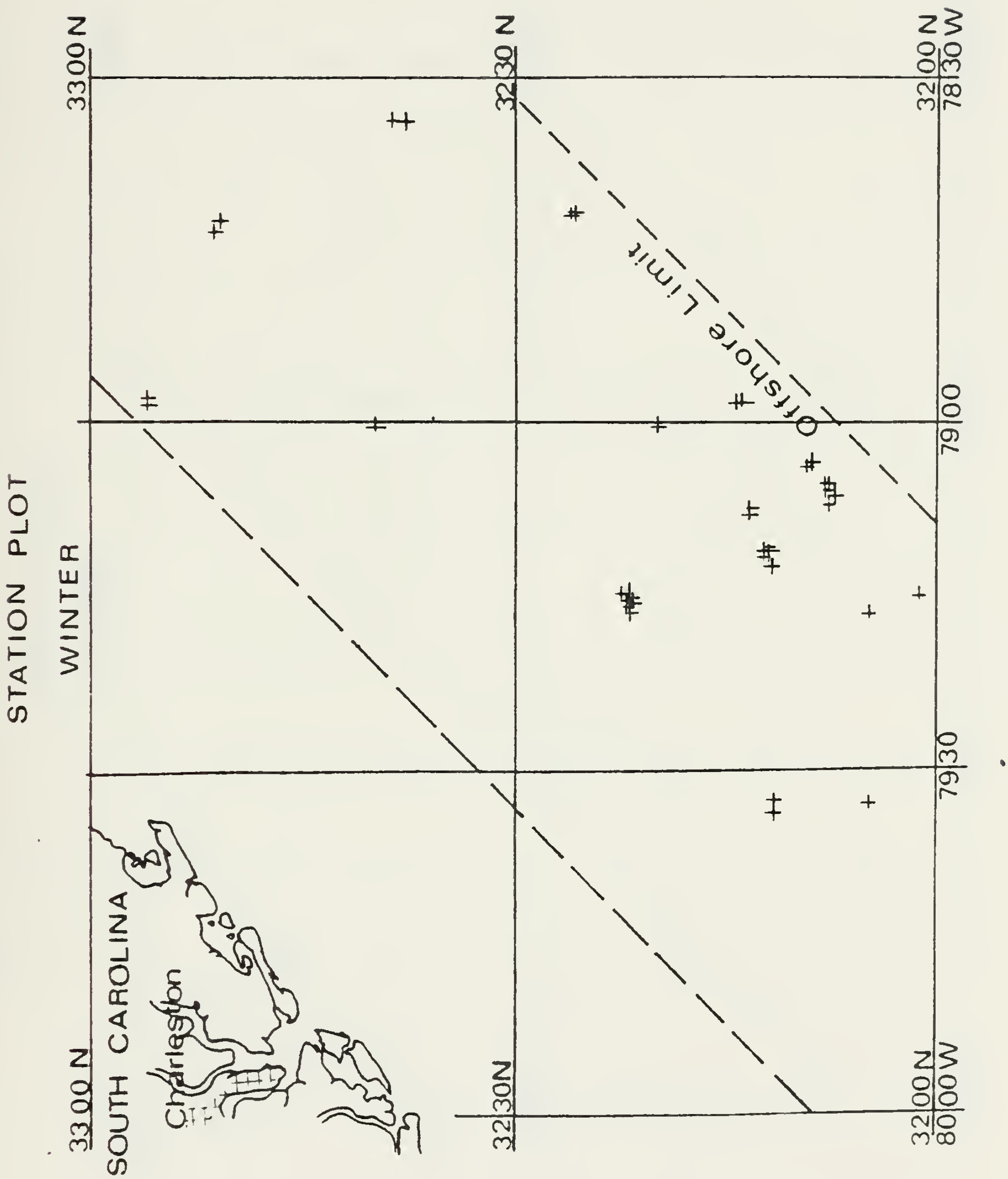
TEMDAT PROFILES – REGION II



(Note: Maximum and minimum profiles represent composites of all stations)

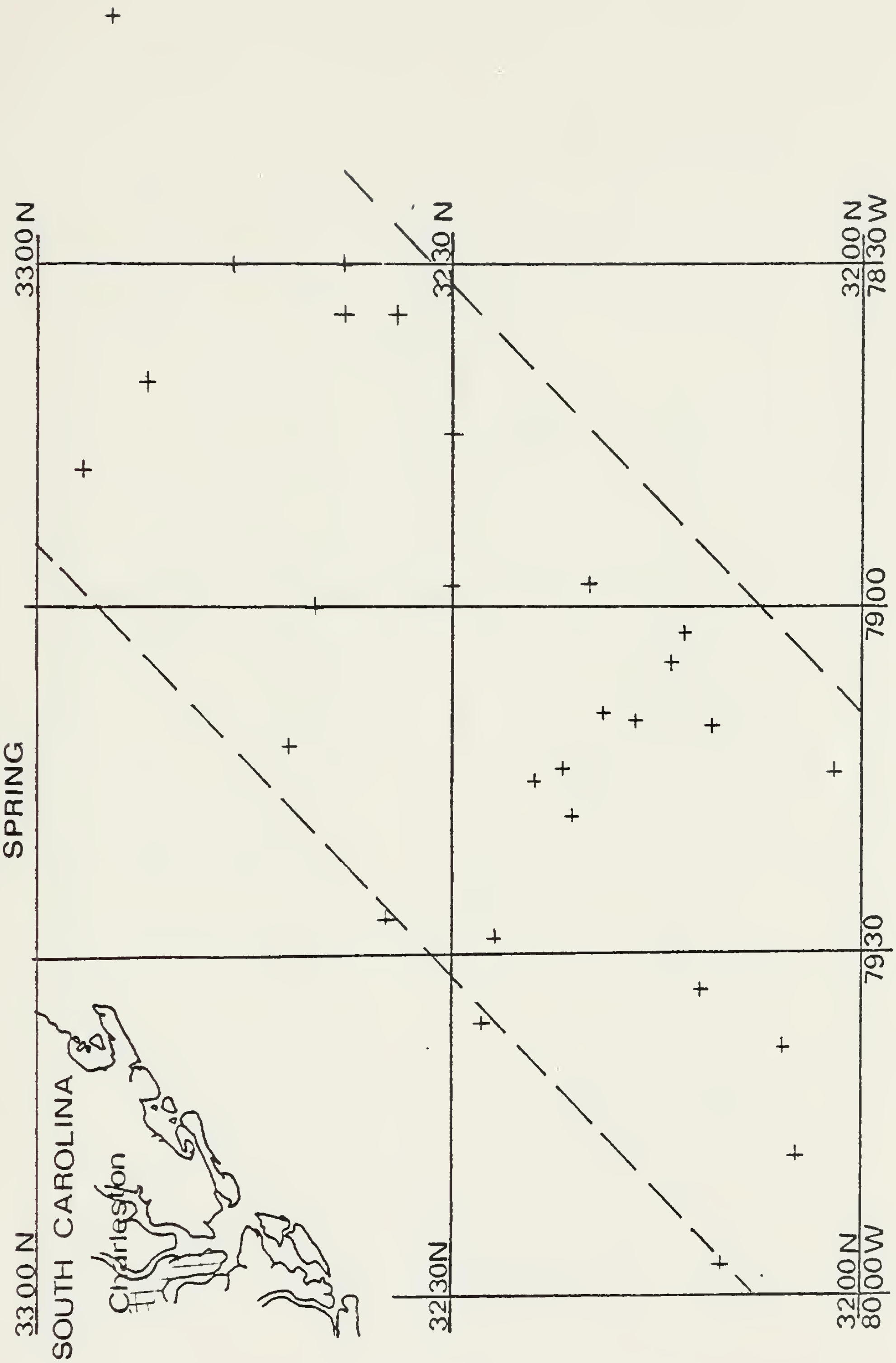
SALDAT PROFILES - Region II

Appendix 3:
Station Location Plots



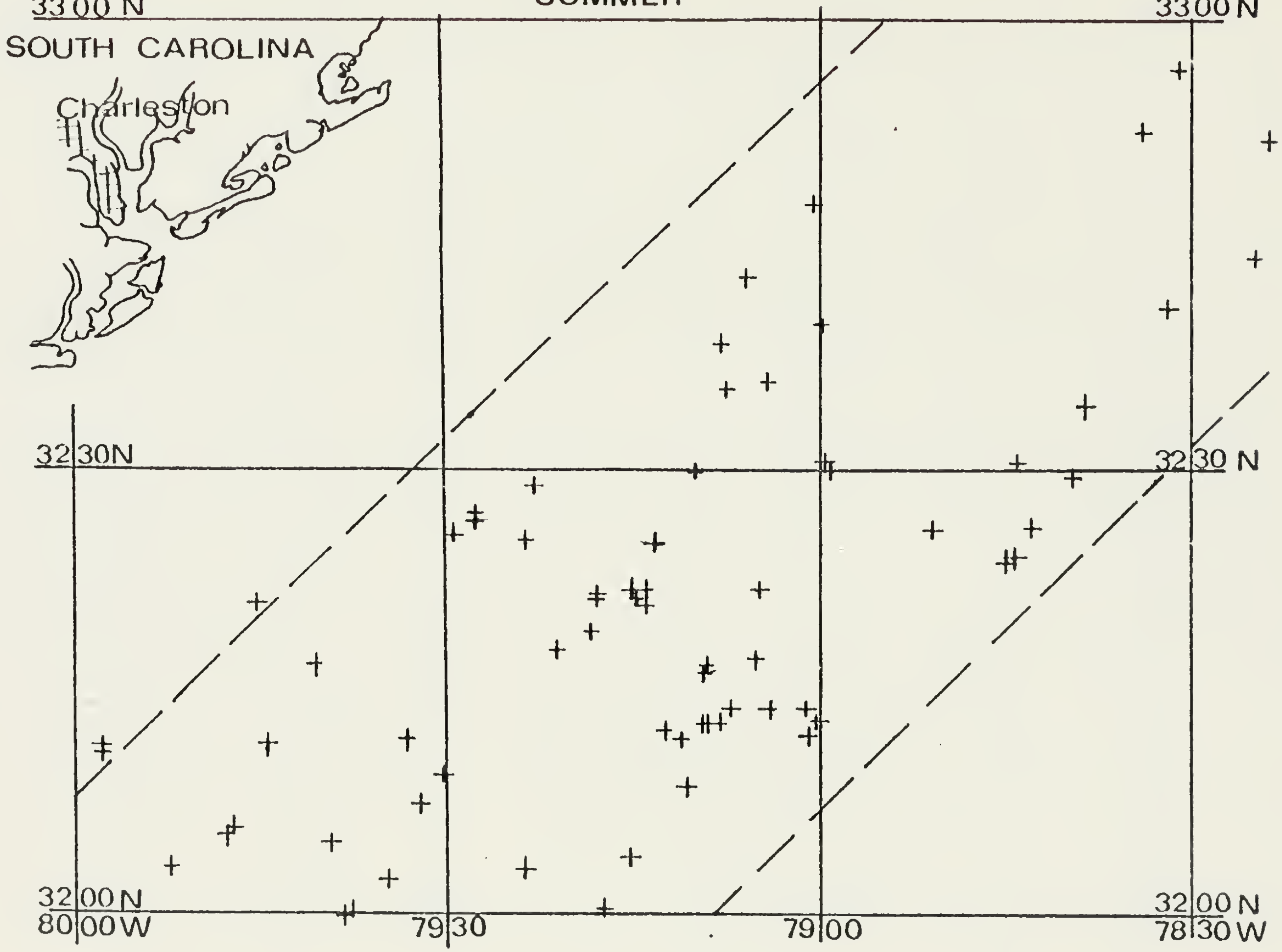
STATION PLOT

SPRING



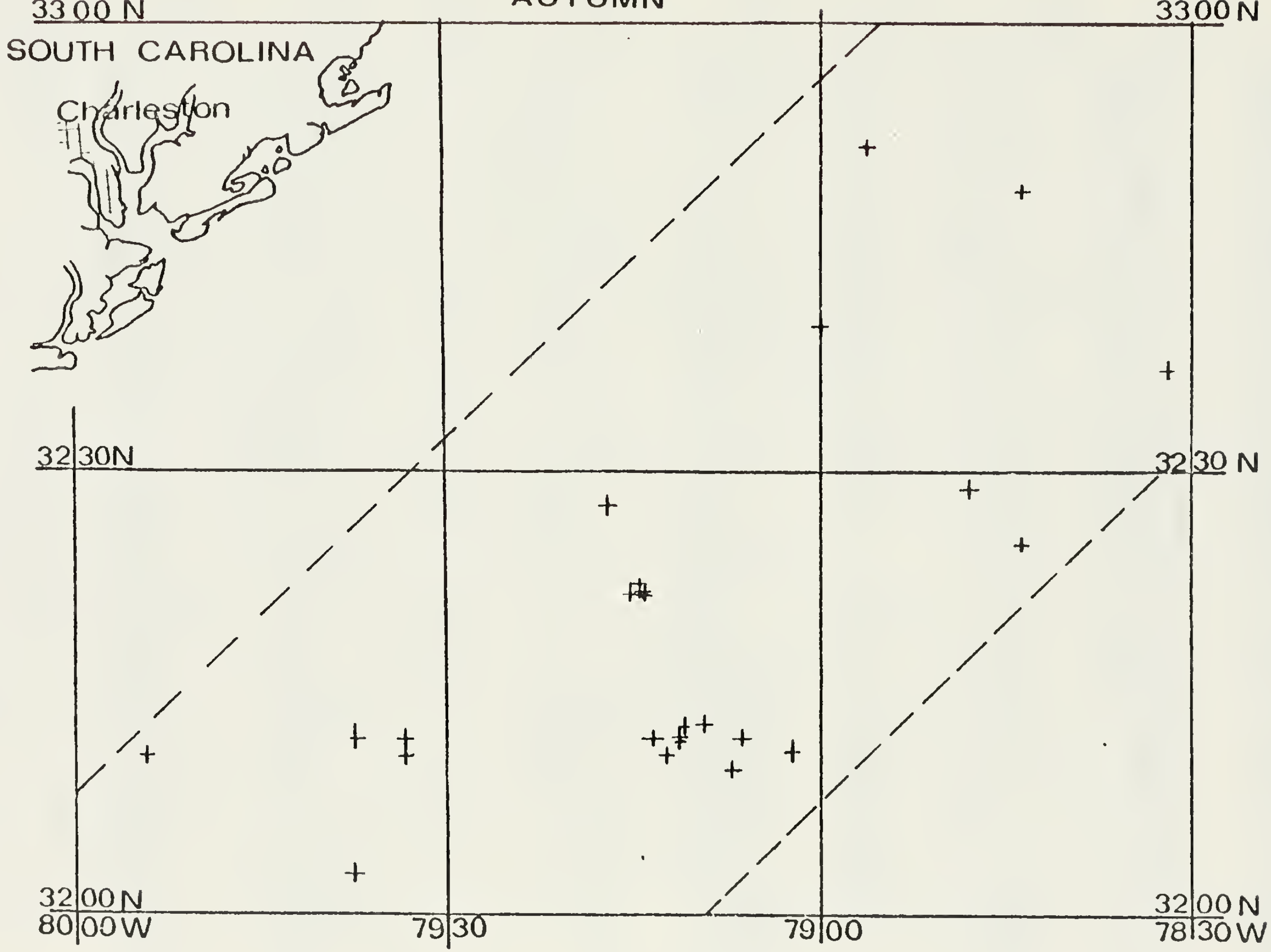
STATION PLOT

SUMMER



STATION PLOT

AUTUMN



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Coastal controls on vertical sound speed determination and corrections to echo soundings.